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The Commonwealth of Massachusetts

Executive Office for Administration and Finance

A DATA COMMUNICATIONS PLAN FOR THE COMMONWEALTH

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Interim Report

Office of Management Information Systems

Bureau for Systems Policy & Planning

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FOREWORD

Today, the Commonwealth of Massachusetts has an unprecedented opportunity to strengthen the efficiency and effectiveness of its government operations, by harnessing emerging data communciations technologies.

The divestiture of AT&T and associated deregulation of the telecommunications industry have had a profound and continuing effect on the variety, quality, and cost of data communications equipment and services available in the marketplace. At the same time, the Commonwealth faces increasingly sophisticated data communications demands from growing numbers of state agencies.

In evaluating these demands and the technological options available to meet them, state government decision makers must be mindful of the necessity both to maintain the quality and to contain the cost of public sector data communications. During FY'85, the Commonwealth's data communications costs exceeded $1 million. Unless changes are made, by FY'95 these costs are expected to exceed $10 million.

In conformance with the legislative mandate for statewide planning and cost control, and in recognition of the sizeable opportunity and responsibility that planning in the area of data communications represents, the Executive Office for Administration and Finance in November 1984 commissioned a study from the Commonwealth's Office of Management Information Systems. The study was to provide the Commonwealth with a framework for data communications planning and development. The result was to be a price/performance management plan that would facilitate taking cost-effective advantage of new technologies to meet the Commonwealth's current and future data communications requirements. That plan, The Data Communications Plan, follows.

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EXECUTIVE SUMMARY

Background

In December 1984, the Office of Management Information Systems initiated a study to assess the current status of the Commonwealth of Massachusetts' major data centers. The study findings were to serve as the basis for the state's first Data Communications Plan. Information was collected on all leased data circuits, their routes, equipment, and costs. This information was gathered by interviewing managers and technical personnel at the Commonwealth's data centers and at major customer agencies. Supplemental information was obtained from the New England Telephone Company. The data were then analyzed to determine a plan for increasing efficiency in the use of data communications technology and for providing cost-effective solutions to meet current and predicted customer demand.

Findings

The Commonwealth is leasing 388 data circuits, with 1001 data terminations. Eighty-eight of these circuits cross the Local Access and Transportation Area (*LATA*) boundary (the line between the 617 and 413 area codes). Expenditures for data circuits exceed $113,000 per month. Seventy-three per cent of the circuits are point-to-point. Two hundred and sixty-one cities and towns, 74% of those in the Commonwealth, are serviced by data communications networks. Four thousand, one hundred and eighty-five modems are in use, most of which are rented. Predicted annual data circuit growth ranges from a low of 10% for one data center to a high of 21%.

Recommendations

Based on these findings, OMIS recommends that the Commonwealth:

> Substitute the more expensive, rented modems, for their counterparts available from the OMIS contract (described on page 37).
>
> Replace point-to-point data circuits with multi-drop lines wherever it is cost-effective to do so.
>
> Establish a high speed, high capacity transmission facility ("pipe-line") connecting Boston, Worcester, and Springfield.
>
> Interconnect data centers, where feasible and allowed by security and statutory limitations.

Substitution of leased or purchased contract modems for rented modems would save at least $22,400 a month. Reduced usage of point-to-point circuits and substitution of multi-drop lines or multiplexing would save an additional $3,000 per month. Installation of the proposed pipe-line would save another $10,000 per month. Annual savings, if these recommendations are implemented, would exceed $400,000 a year, or $4 million over ten years.

Calculation of these savings for each data center are presented on page 36.

PROPOSED POLICIES

In response to findings of this study, OMIS will promulgate the following policies:

Modems & Data Communications Equipment must be purchased from the contract unless it is demonstrated that purchasing is not the appropriate solution, or that the equipment on the contract is not suitable.

Telephone Lines selection must be based on the results of a price/performance analysis. Where applicable, Packet Switching must be used. Until the telephone company converts to digital local loops, analog lines must be used unless an alternative is shown to be more appropriate and more cost-effective.

No new **leased lines** will be installed across the LATA boundary once the pipe-line is installed. Current lines must be converted and all new lines must use the pipe-line unless it is shown that this would be unsuitable.

Data centers must be interconnected, subject to security requirements, statute and technology limitations, as a cost-effective alternative to connecting individual terminals to "foreign" data centers.

DIVESTITURE

The impact of divestiture on data communications in the Commonwealth has been two-fold.[1] It resulted in significantly altered boundaries, both geographic and regulatory, with corresponding changes in service delivery. And it lowered the barrier to competition from new vendors of existing and new technologies, thus offering the Commonwealth new opportunities to maximize the cost-effectiveness with which it meets its data communications needs. A discussion of both types of impact follows.

---

[1] Major portions of the Modified Final Judgement through which divestiture was implemented went into effect January 1, 1984.

Boundaries

In the Modified Final Judgement (MFJ), the settlement of the United States' antitrust suit against AT&T provided for a division of duties between AT&T and the newly established Regional Operating Companies, as well as for the introduction of the mechanism to be used by competitive interexchange (long distance) carriers such as MCI, Sprint, and Allnet. Local Access and Transportation Areas (LATAs) were established to isolate long distance service from local service.

AT&T continues to provide interexchange service, which was defined under the MFJ to be inter-LATA service, and the Regional Operating Companies provide local service and intra-LATA service. The LATA configuration in Massachusetts follows the area code boundaries, 413 and 617. As a result, there now exist within the Commonwealth two categories; inter-LATA (calls between the 617 and 413 areas) and intra-LATA (calls within 617 or 413). The Massachusetts Department of Public Utilities (DPU) has jurisdiction over intrastate matters in both categories. The Federal Communications Commission (FCC) has retained control over interstate and inter-Lata matters.

The local telephone company has a monopoly on the provision of local service within LATAs. According to the MFJ, the telephone company must also provide a gateway for the interexchange, or common carriers, with eventual equal access required for AT&T and the other common carriers.

Under the terms of divestiture, New England Telephone Company (NET) and its parent, NYNEX, can service intra-LATA telephone calls (i.e.; those telephone calls wholly within the 617 or 413 area code), but are specifically prohibited from handling inter-LATA traffic (calls between the 617 and 413 area codes). The common carriers, AT&T Communications (the regulated arm of the deregulated Bell System) MCI, Sprint, and Allnet, handle the inter-LATA traffic, but are specifically prohibited from handling intra-LATA traffic.

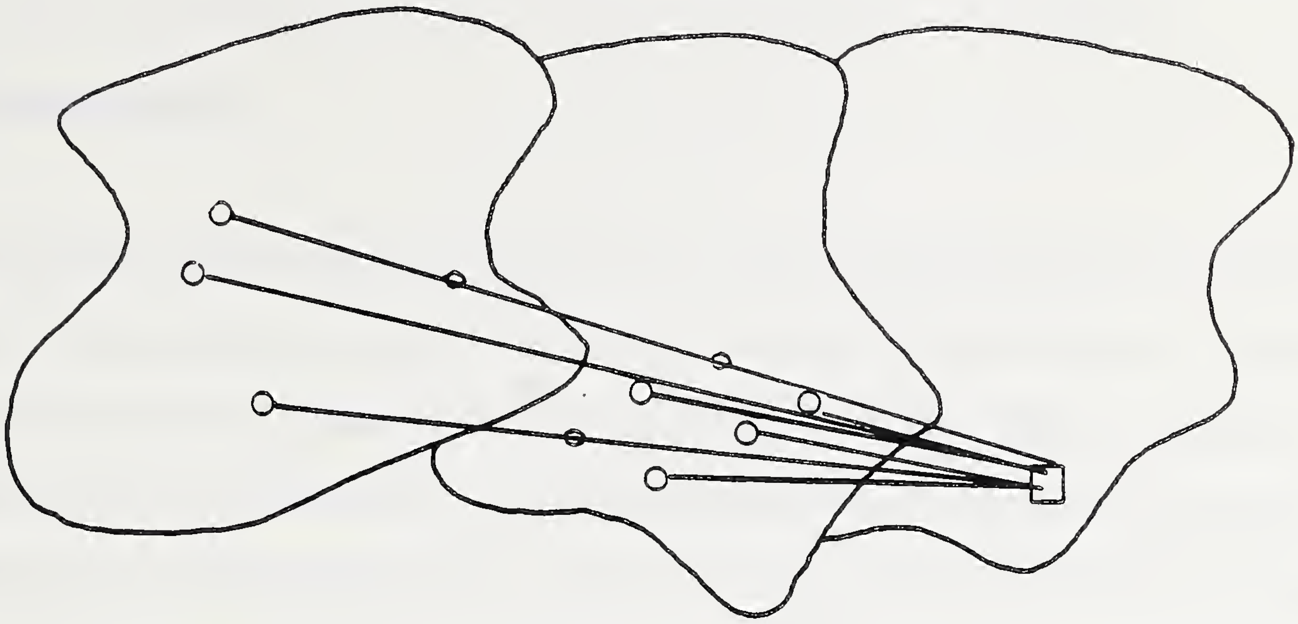
To date, the greatest impact of divestiture on the Commonwealth is the loss of Telpak rates between LATAs. Telpak is the name that NET has given to a volume discount leased circuit arrangement for large users. The loss of Telpak to the western part of the State has caused a significant increase in inter-LATA circuit costs.

Divestiture and the associated loss of Telpak as a link between the eastern and western parts of the state precipitated reevaluation of the Commonwealth's data circuit installation and usage practices. On the next page are two pictorials that represent the method employed before divestiture and the proposed method after divestiture for all state-wide data communications.

---

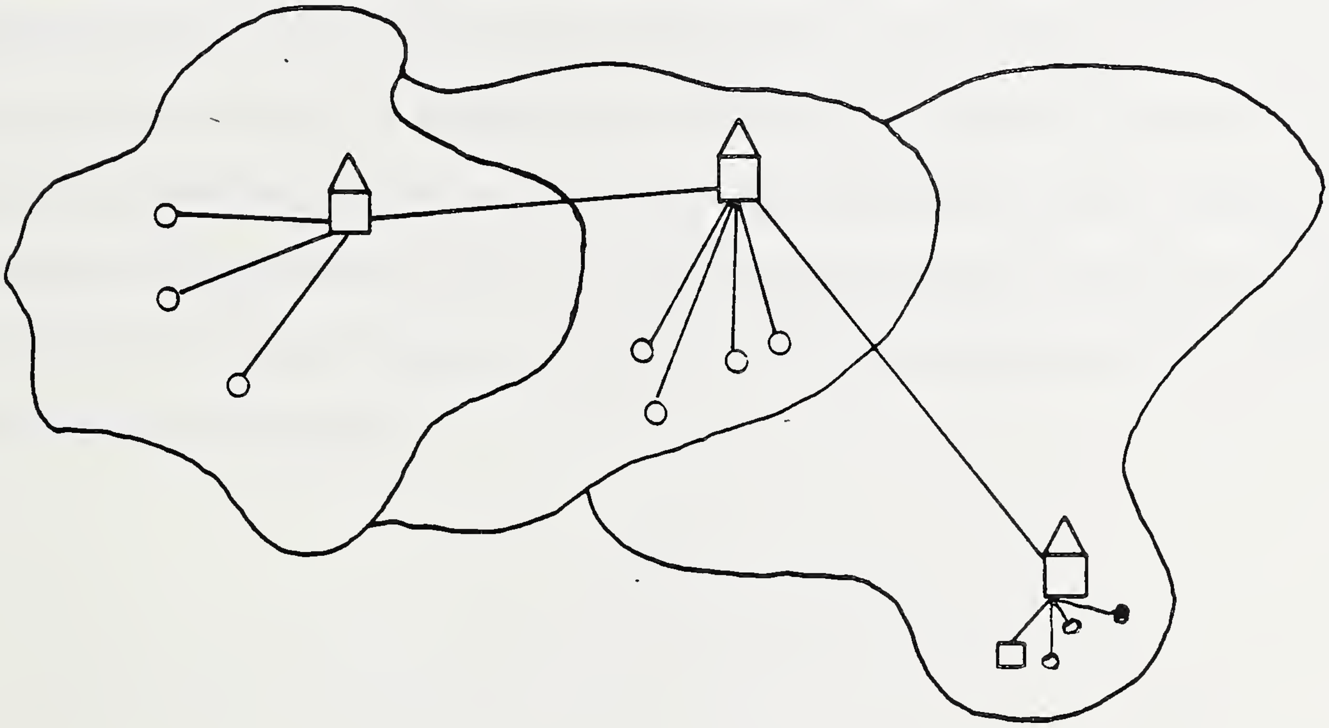
[1] A map of Telpak facilities in Massachusetts is provided in the Appendix on page 88.

State-wide Data Communications Methodology: Before Divestiture



A circuit starts at a data center in Boston and proceeds to its destinations. With the imposition of the LATA boundaries, this methodology is no longer cost-effective.

State-wide Data Communications Methodology: After Divestiture



Intelligent switching nodes, attached to high speed trunk lines, carry data to central points. The data are then distributed by local circuits from these nodes.

Technologies

The argument used to justify the break up of AT&T, that the monopoly was constraining product development and competition, appears to have been well founded. Since divestiture, numerous new technologies and new producers of technology have appeared in the marketplace. As a consequence, the data communications environment is currently a turbulent one. Prices change daily. A final decision on the access charge recommended in the MFJ for business lines has yet to be reached; in the interim, implementation of this charge fluctuates. Local cost containment efforts are hampered due to the loss of arrangements like TELPAK and the subsidy from long distance telephone usage. One apparent avenue for cost containment is to reduce lines; however, this could result in penalties for nondelivery of mandated services that outweigh intended monetary savings. New companies, offering new options for telephone equipment and maintenance, are springing up every day, but these start-ups inevitably lack any track record with which to compare them against the Bell System. AT&T, too, has changed in response to the boundary changes described above; ATT-COM is providing inter-LATA communications and all long-distance communication, while ATT-IS has been deregulated to provide equipment and consulting, but no circuit capacity. As a result, the Commonwealth has been forced into a multi-vendor environment.

I. THE COMMONWEALTH'S CURRENT NETWORK

Data Collection: Focus

Boston, Worcester, and Springfield are the Commonwealth's largest cities. Their associated Primary Metropolitan State Areas encompass over 63% of the Commonwealth's population. Eighty-one percent of that population is within 25 miles of these three population centers, and therefore can be serviced by local circuits. In light of the fact that these cities fall along one line (East-West), it seemed likely that they would be serviced most cost-effectively by a single trunk line. This supposition, or hypothesis, provided a focus for data collection.

Compiling An Inventory

Developing a State Data Communications Plan first required becoming familiar with the current network. For this purpose, information was gathered on all telephone lines used for data within the Commonwealth. This included public switched analog lines, private analog lines, and private digital circuits.[1]

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[1] Because planning for voice circuits is the responsibility of the Office of Telecommunications, only information relating to data communications was gathered for this study.

In addition, descriptive information was obtained on data communications equipment (modems and multiplexers), and on equipment and line costs. This information was obtained from relevant state government agencies, and from the New England Telephone Company.

Data collection entailed conducting site visits to the Commonwealth's major data centers. These visits also served as an opportunity to provide key personnel with an overview of the network project. A list of the organizations and individuals that participated in this data gathering effort appears in the Appendix on page 71.

Inventory Data Analysis

A relational data base model was created to facilitate data analysis.[1] Using this model, analyses were performed on the type and use of circuits and terminations, the location of circuit terminations, and the type and speed of modems. These analyses produced findings about the Commonwealth's current network, which are summarized in the Executive Summary and reported in more detail below.

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[1] The data base schema appears in the Appendix on page 74.

Circuits and Terminations

The table that follows documents service to the Commonwealth's cities and towns and compares characteristics of the circuits in the Commonwealth within major categories: intra-LATA versus inter-LATA, analog versus digital, and point-to-point versus multi-drop. The table also displays the distribution of point-to point versus multi-drop terminations.

DATA COMMUNICATION SERVICE TO THE COMMONWEALTH

CITIES & TOWNS SERVICED

Total number of Cities and Towns	351
with terminals	261 (74%)
without terminals	90 (26%)

CIRCUITS

	Not including the Lottery	Including the Lottery[1]
intra-LATA	338 (87%)	590 (87%)
inter-LATA	50 (13%)	88 (13%)
TOTAL	388	678
analog	359 (93%)	649 (96%)
digital	29 (7%)	29 (4%)
TOTAL	388	678
point to point	284 (73%)	284 (42%)
multi-drop	104 (27%)	394 (58%)
TOTAL	388	678

TERMINATIONS

point-to-point	284 (28%)	284 (7%)
multi-drop	613 (61%)	3223 (85%)
(leg circuits)[2]	104 (10%)	290 (7%)
TOTAL	1001	3797

---

[1] Because of the enormity and special purpose of the Lottery Commission network, Lottery information was not included in most analyses performed for this study. Where it was included, that is noted.

[2] Leg circuits, also called master circuits, are the part of a multi-drop circuit that connects the computer center to the telephone company.

The 388 circuits and 1001 terminations noted in the table on the preceeding page (Data Communication Service to the Commonwealth), are distributed among data centers as follows:

DATA CENTER CIRCUITS

DATA CENTER[1]	NUMBER OF CIRCUITS	NUMBER OF TERMINATIONS
CHSB	33	368
OMIS/BCS	84	237
DES	138	156
Trial Courts	16	93
RMV	31	53
DOR	23	31
RCN	29	29
DOC	28	28
EOEA	3	3
Treasury	3	3
TOTAL:	388	1001

The charts that follow depict the distribution and costs of data circuits across the state, by data center.

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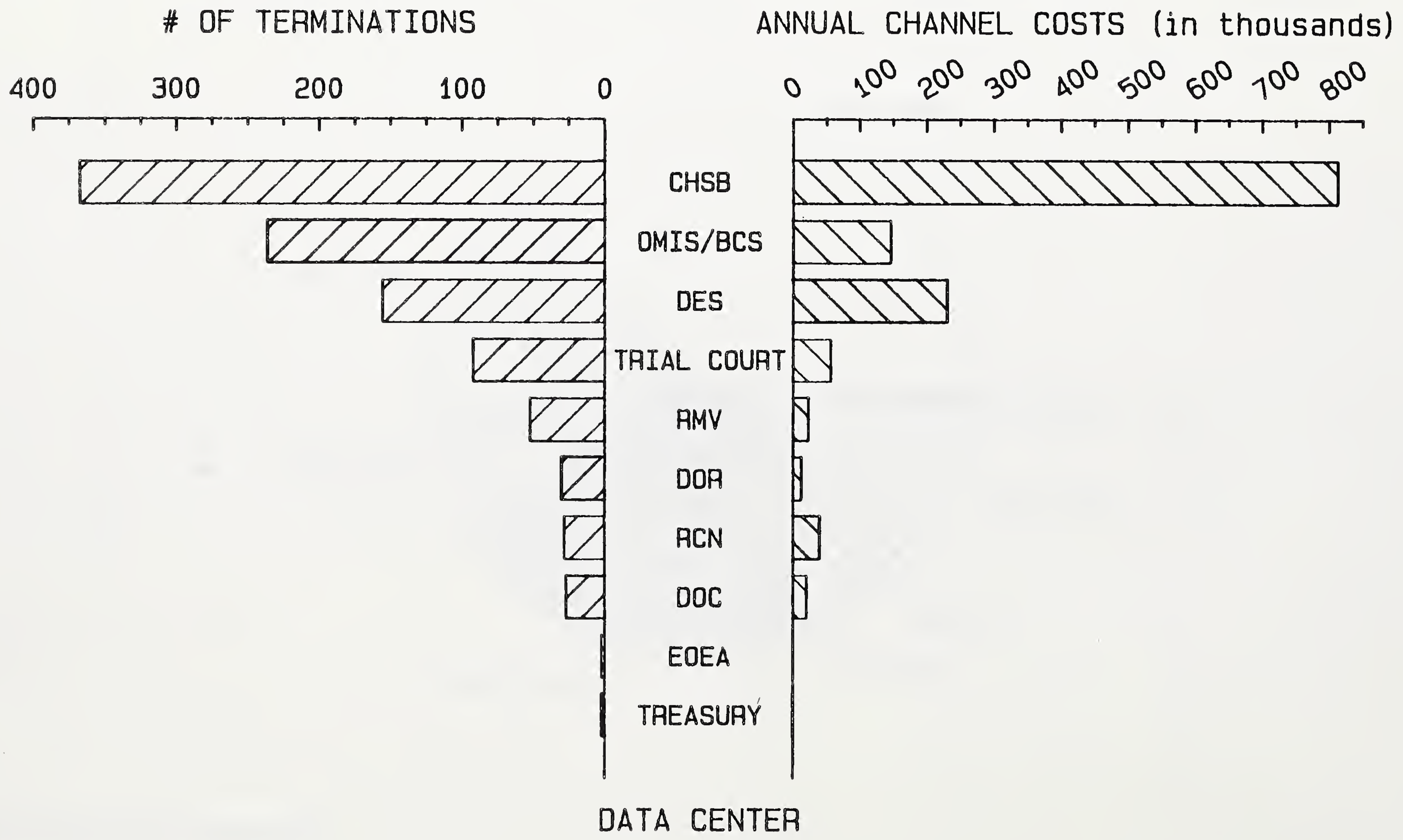
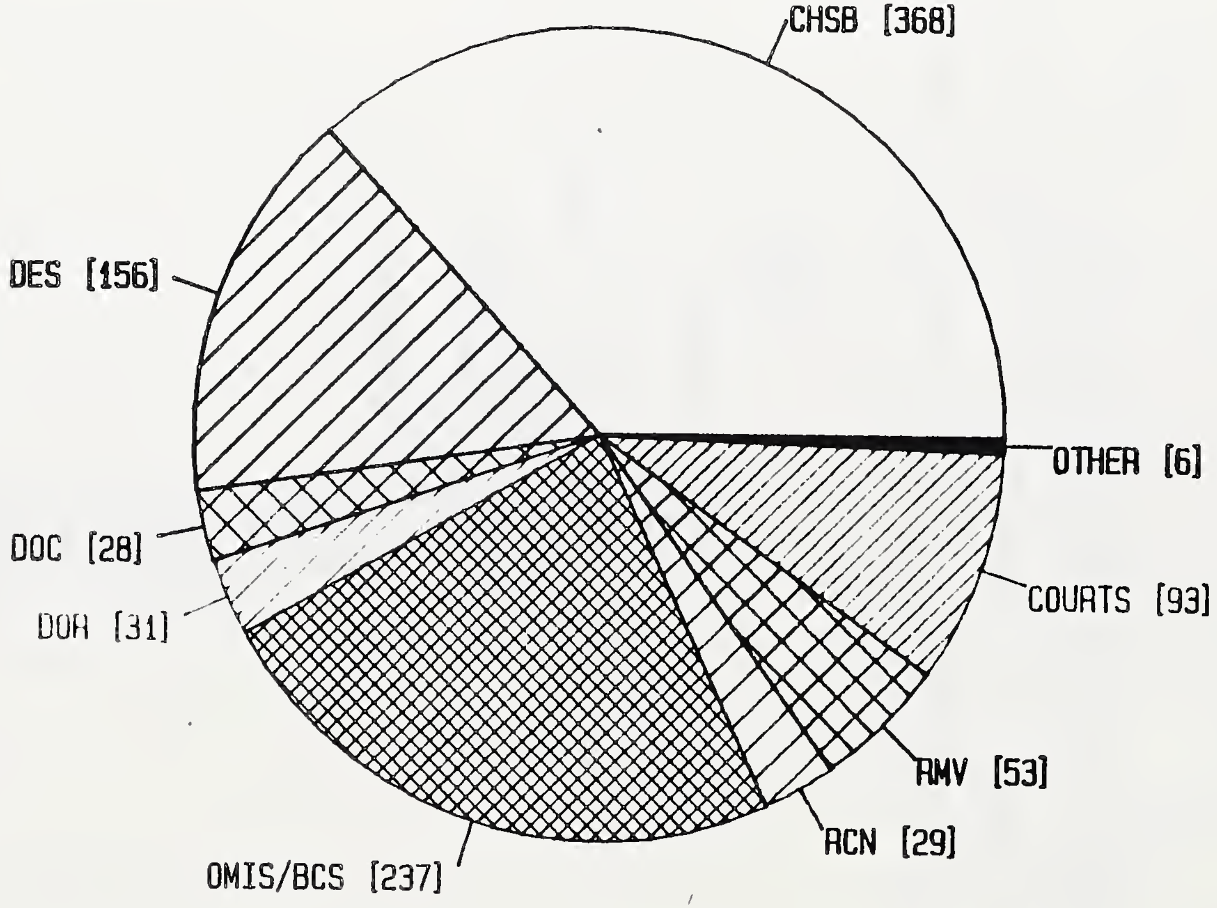
[1] A listing of complete department names is contained in the Appendix on page 73.

BSPP NETWORK SURVEY
Data Center Size vs. Expenditures



DATA CENTER CIRCUIT SUPPORT

FEBRUARY 1985



NUMBER OF DATA CIRCUIT TERMINATIONS

BSPP NETWORK SURVEY - 1985

The 1001 terminations can be categorized by customer departments as follows:

DATA COMMUNICATION CIRCUITS BY DEPARTMENT

DEPARTMENT[1]	NUMBER OF CIRCUIT DROPS
CHSB	368
DES	157
Trial Courts	93
Welfare	90
DSS	64
RMV	50
DOR	34
DOC	29
RCN	29
DMH	28
DPH	15
DYS	8
EOEA	4
PMIS	4
Mass Rehabilitation	3
OMIS/BCS	3
Group Insurance	2
State University	2
Treasury	3
Community Colleges	1
DEQE	1
DOE	1
Uncategorized	12
TOTAL:	1001

A set of detailed circuit maps for each of the Commonwealth's data centers follows. Maps for the Executive Office of Environmental Affairs and the Treasury are not included, since all of their data circuits lie within the Boston area.

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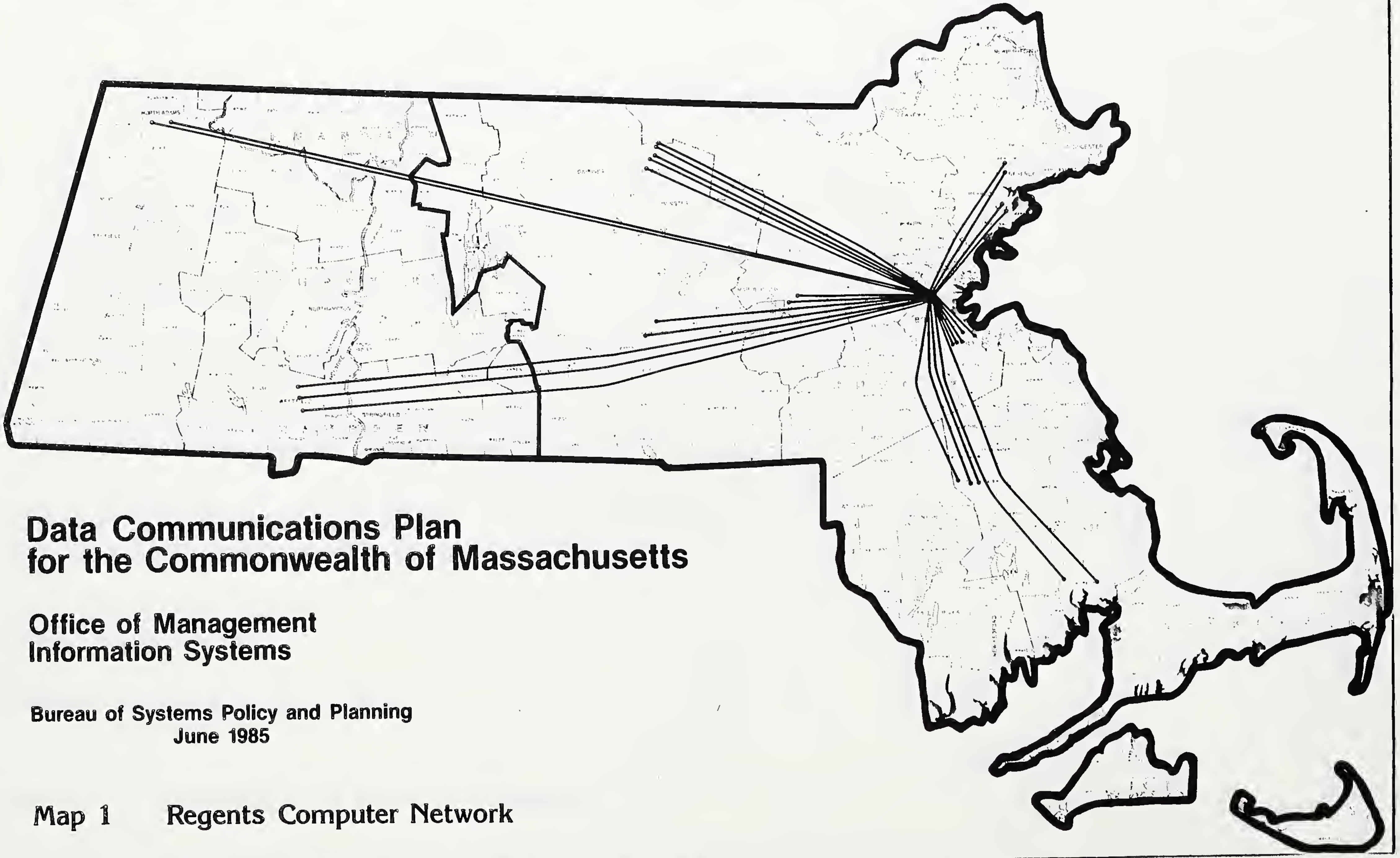
[1] A listing of complete department names is contained in the Appendix on page 73.

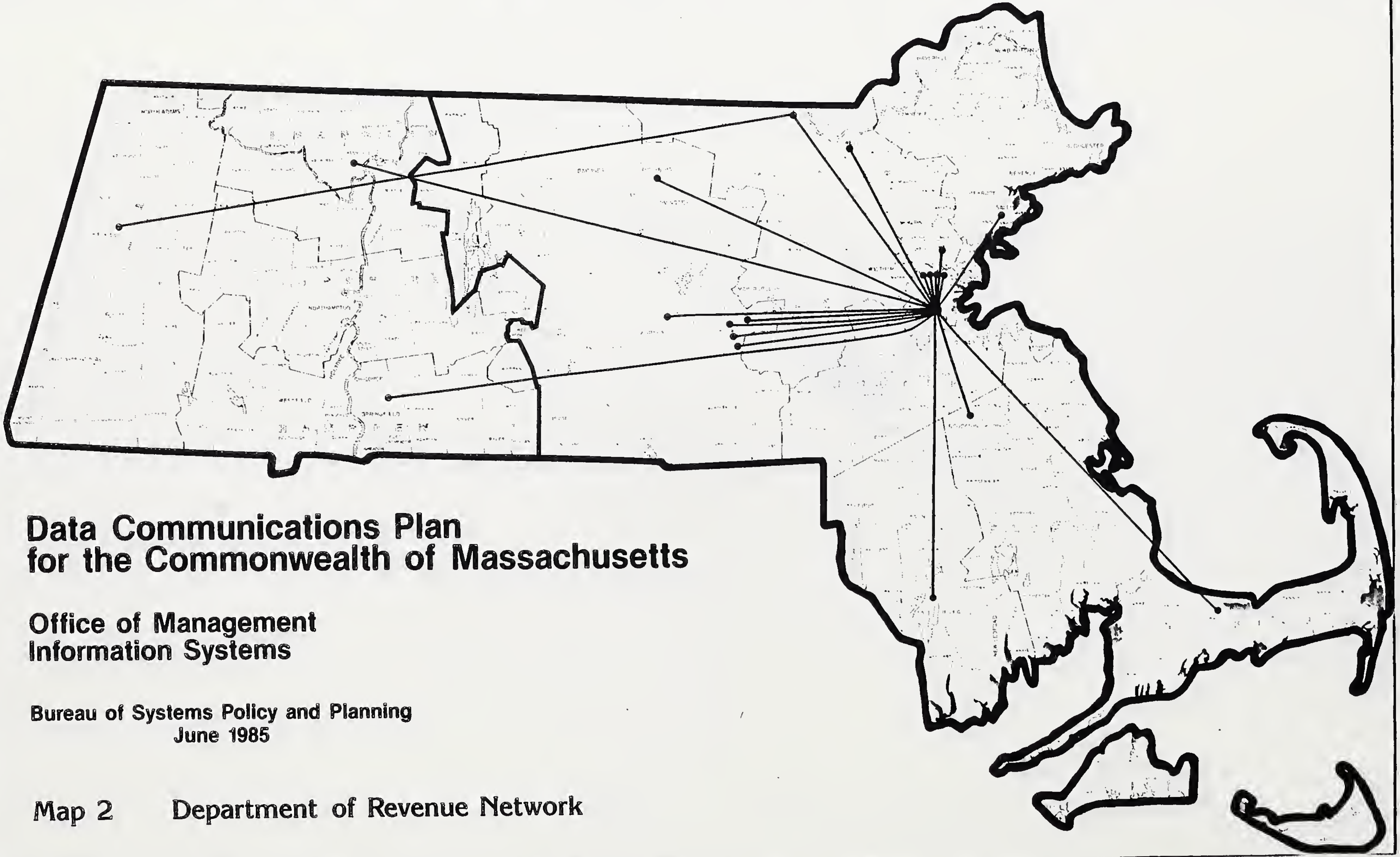


Data Communications Plan
for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 1 Regents Computer Network

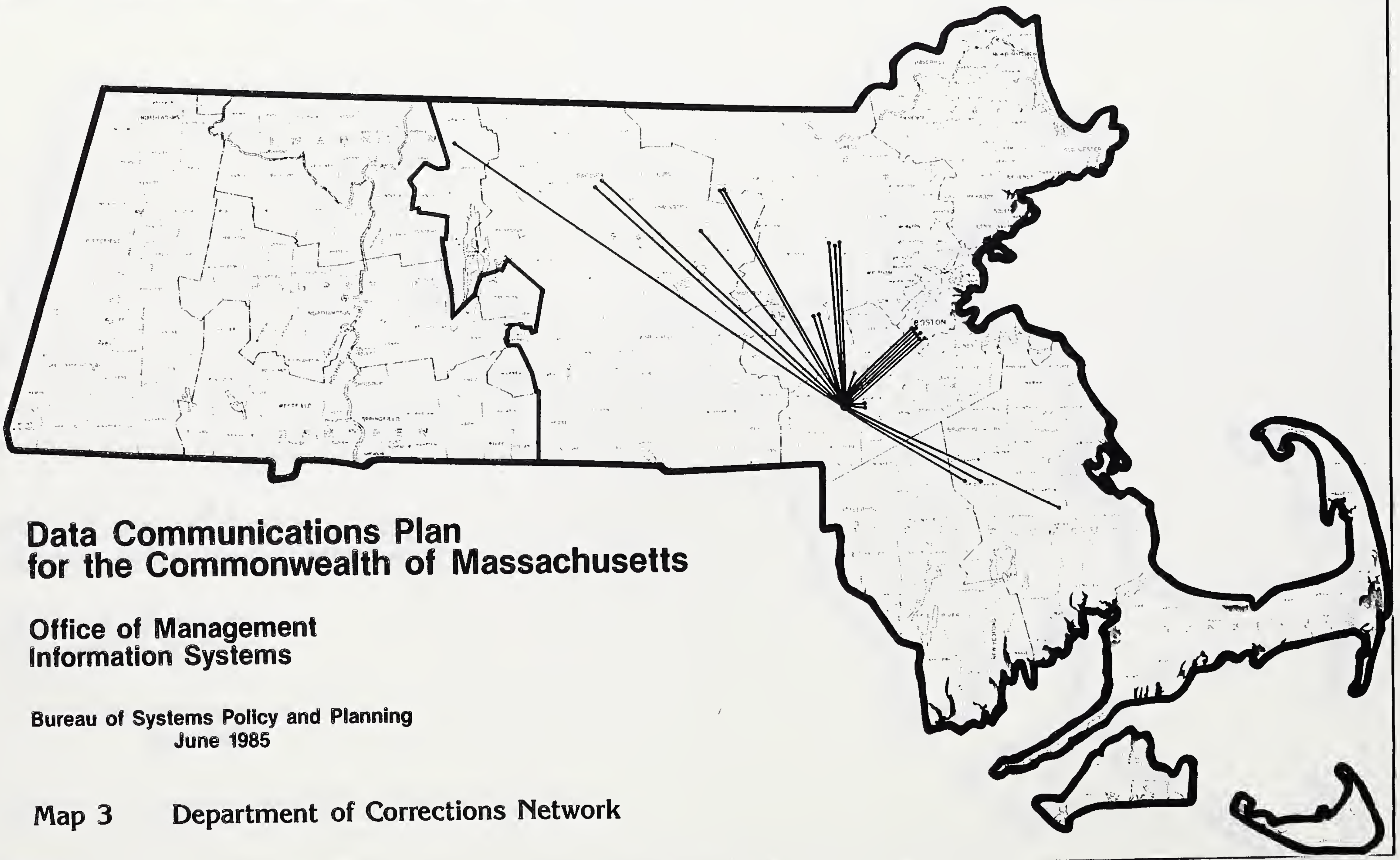


Data Communications Plan
for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 2 Department of Revenue Network

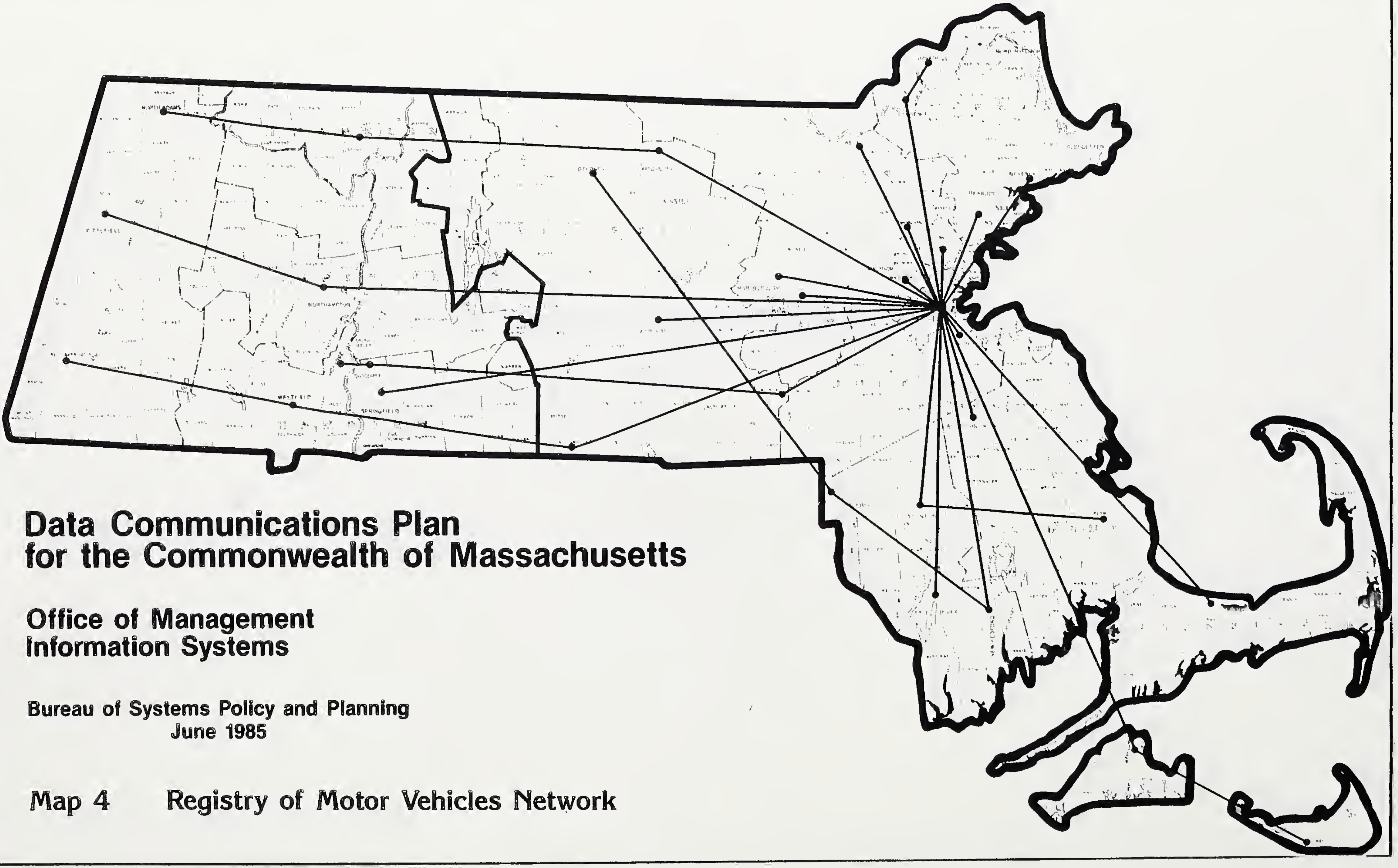


Data Communications Plan for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 3 Department of Corrections Network

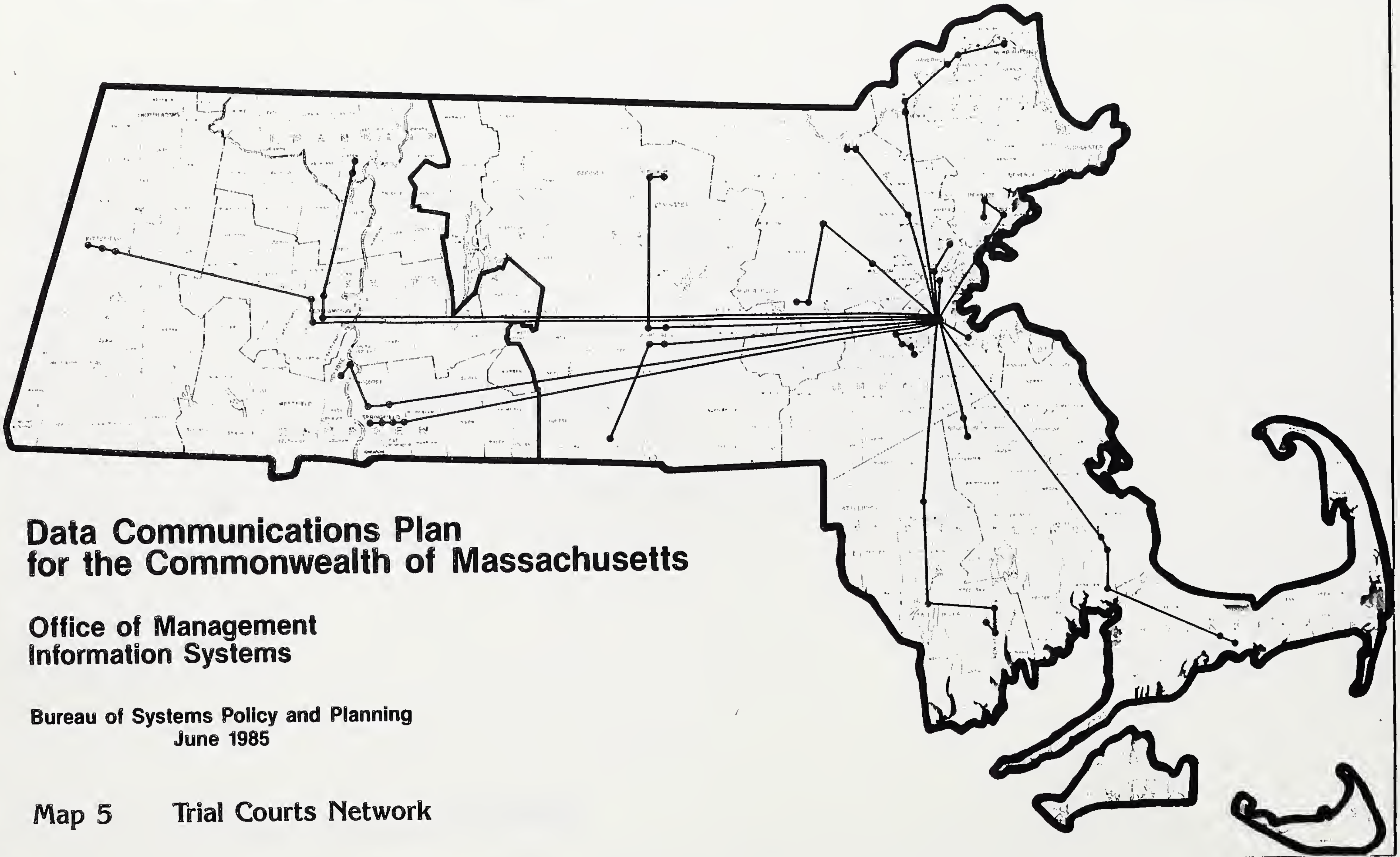


Data Communications Plan for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 4 Registry of Motor Vehicles Network

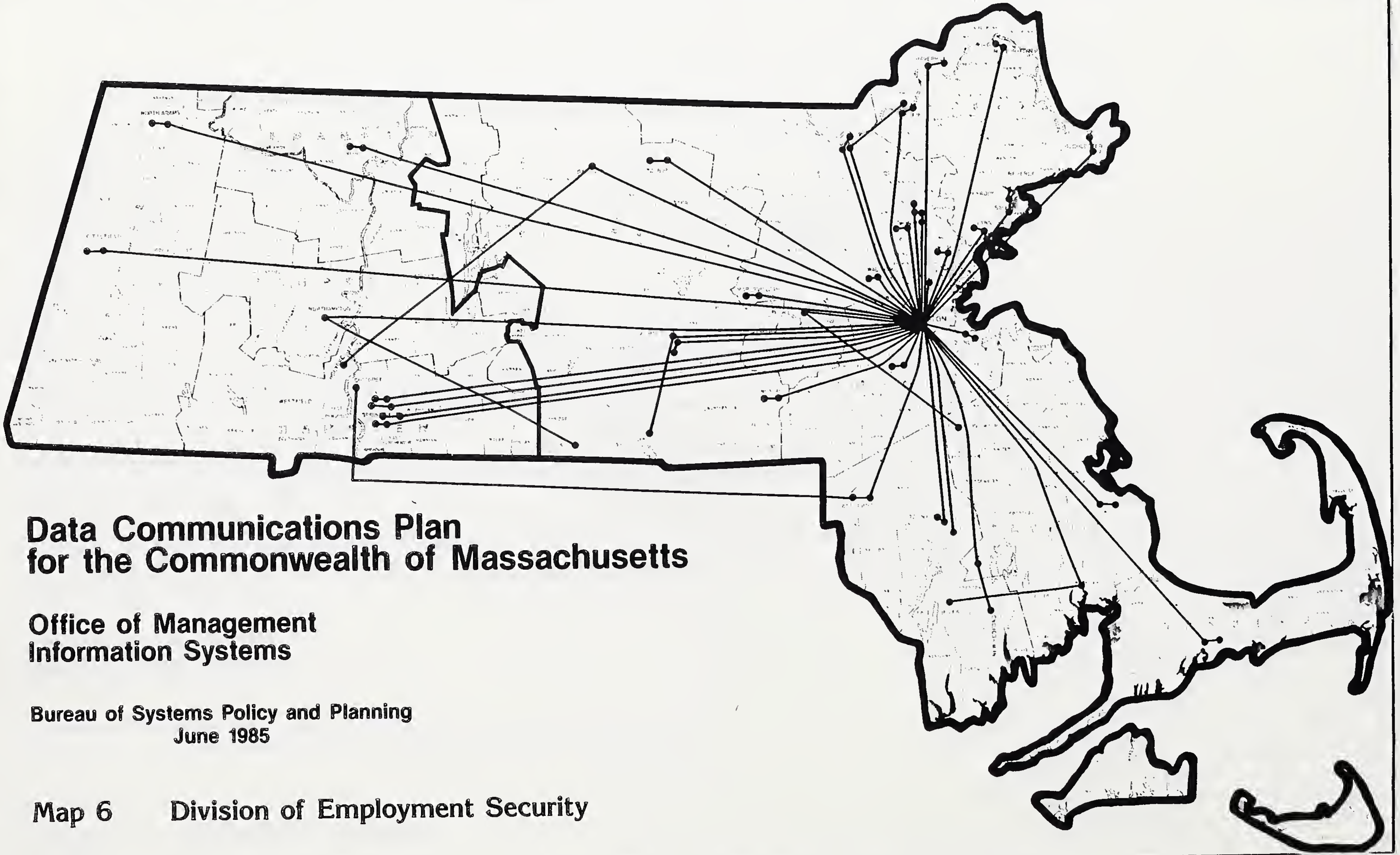


Data Communications Plan for the Commonwealth of Massachusetts

Office of Management Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 5 Trial Courts Network

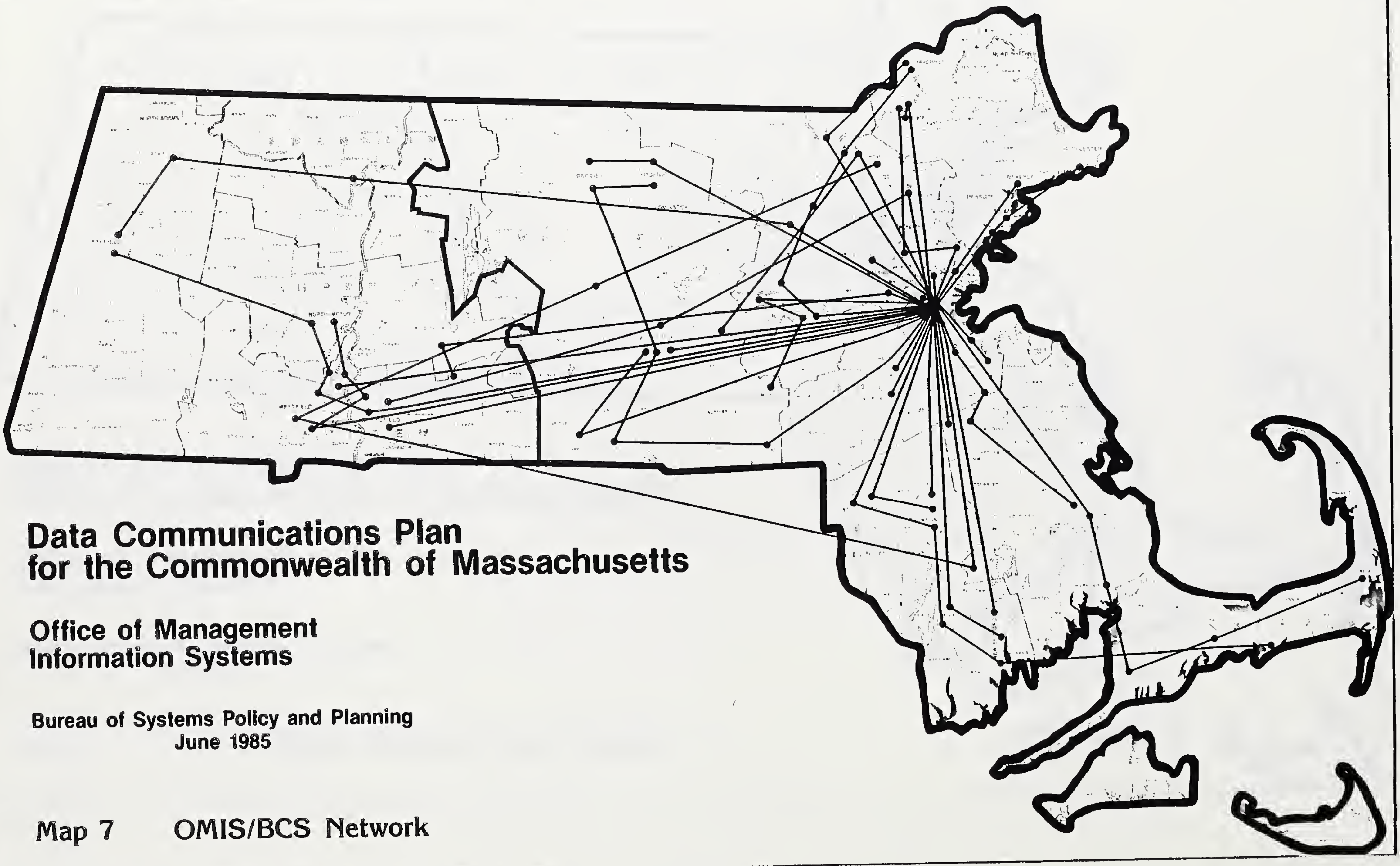


Data Communications Plan for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 6 Division of Employment Security

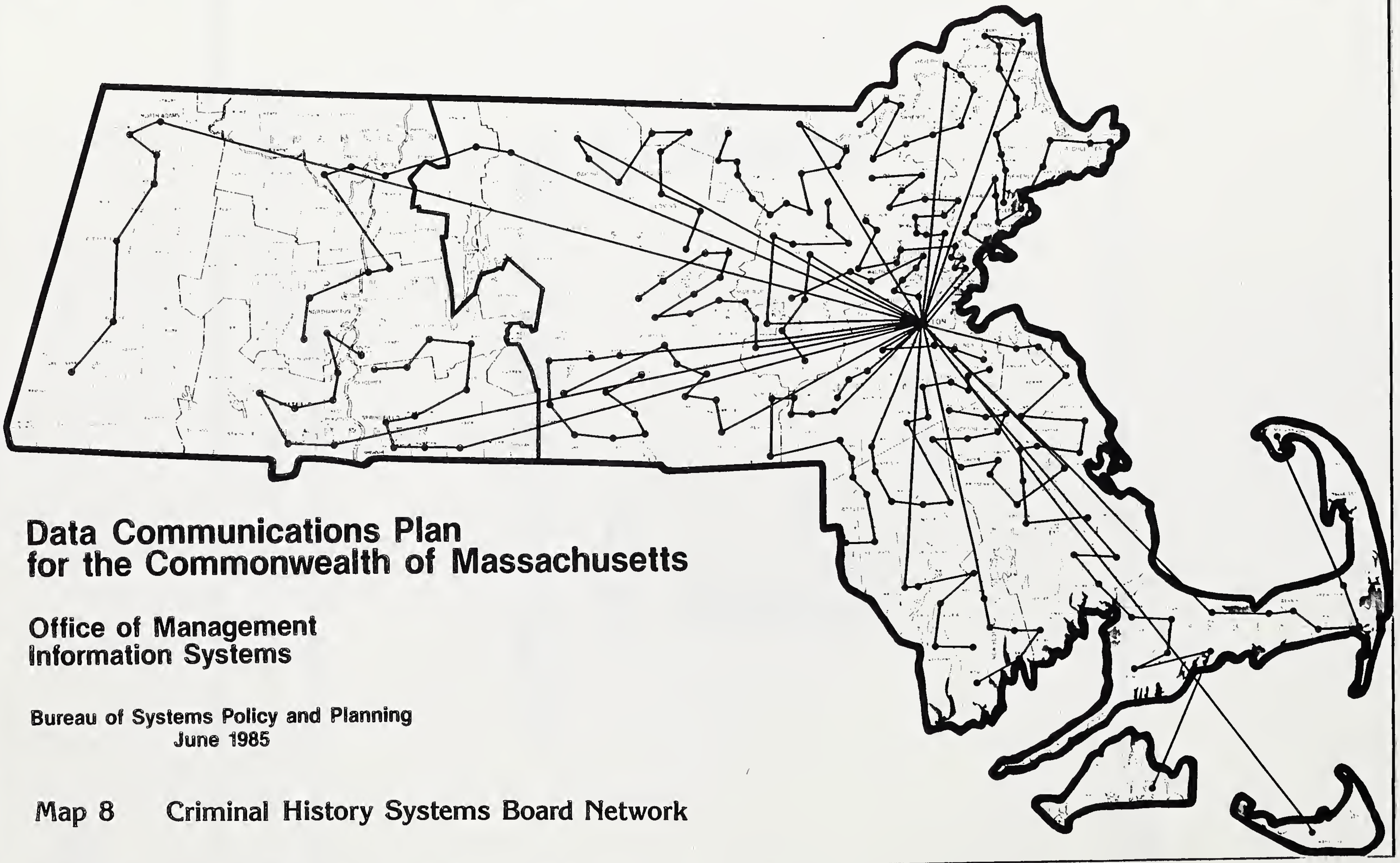


Data Communications Plan
for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 7 OMIS/BCS Network



Data Communications Plan for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 8 Criminal History Systems Board Network

Modems

The table below displays the distribution of modems in the Commonwealth's current network according to speed.[1] It is worth noting that all of the low speed (150 bps) modems will be eliminated during 1986 as a result of network redesigns.

DISTRIBUTION OF MODEMS BY SPEED

SPEED (bps)	NUMBER
150	221
1200	62
1800	2900 *
2400	10
4800	490
4800 (digital)	374
9600	110
14,400	16
19,200	4

*Lottery Commission

---

[1] Eleven different manufacturers provide these modems. An enumeration by manufacturer and speed appears in the Appendix on page 78.

Data circuit speed is a major factor in the determination of network design and capacity. The vast majority of circuits in the Commonwealth (93%) are analog; their speeds are determined exclusively by the modems that are attached to them. [1]

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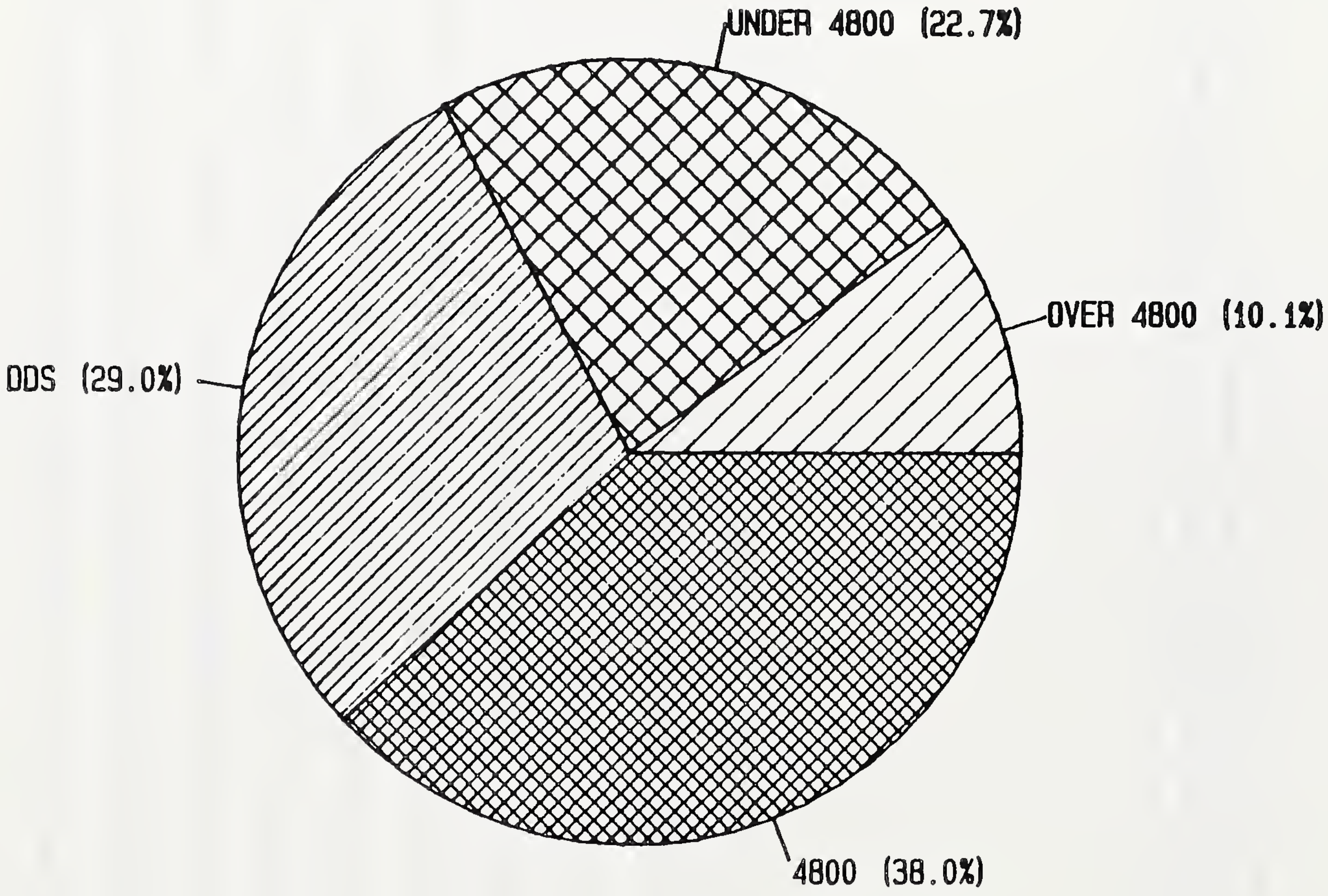
[1] By contrast, digital circuits (DDS - Digital Dataphone Service) are engineered for a particular speed. The chart on the following page illustrates the distribution of circuits by speed.

BSPP NETWORK INVENTORY
DATA CIRCUIT SPEEDS



speeds listed in Bits Per Second

BSPP - 3/85

II. ANALYSIS

In addition to becoming familiar with the Commonwealth's current network, developing a State Data Communications Plan required analysis of the predicted network growth and the cost of such growth.

Data communications costs are in some respects quite complicated, and are usually presented in a Punch Card Account Billing Report (PCAB), a formidable and, as the name suggests, antiquated report produced by the telephone company. A cursory review for this study revealed significant billing errors for some data lines. Because Commonwealth agencies do not have the manpower to check all of their telephone bills, each department's cost figures were calculated by OMIS for this study, with cooperation and assistance from department personnel. Cost increases were calculated using the telephone company's estimated annual rate increase, 4.7%. Data center growth rate was determined based upon figures postulated by data center personnel. Analysis of each data center revealed a compound growth rate varying from a low of 10% per year to a high of 21% per year.[1]

---

[1] A review of past growth indicates that these predictions are quite conservative. Furthermore, entirely new networks such as those currently being planned for the Registry of Motor Vehicles (RMV) System and the Massachusetts Public Assistance Control System (MPACS), are not included in these growth predictions. MPACs alone could add as many as 2000 new data terminals to the Commonwealth's totals.

Findings

The four tables that follow present summary findings of the cost and growth analyses.[1] A conservative, compound growth rate of 17.4%, obtained using a weighted average of the postulated growth rates, was used in the calculations.

The first table in this series presents the channel costs for each data center, together with the number of drops that each maintains and its computed annual channel bill. The "annual 1985" figures are real. The ten year forecast that follows includes an estimated annual 4.7% rate increase by the telphone company. This rate increase has already been filed by NYNEX for 1986. As the table shows, even without growth within any data center, costs will *double* within the forecast period.

---

[1] A set of tables that display the findings in greater detail appears in the Appendix on page 79.

The second table illustrates a ten year forecast of data center growth. At a 17.4% compound growth rate, each data center's service needs will increase five-fold.

The third table isolates the projected growth of voice and data circuits that cross the LATA boundary. Note the changing ratio of data to voice lines.

The fourth table combines the predicted telephone company rate increases from the first table with the data center growth contained in the second table.

As this table clearly shows, if current practices are continued, the Commonwealth's data communications burden will become financially unsupportable within ten years.

The fifth table shows line costs and associated savings, based on enactment of recommendations in this report.

ABSTRACT
TABLE 1
3/85

PROJECTED DATA CENTER LINE COSTS
NO COMPOUND GROWTH
4.7% RATE INCREASES
TEN YEAR FORECAST

DATA CENTER	ANNUAL 1985	1990	1995
CHSB	$814,160.00	$1,024,337.73	$1,288,773.44
DES	$232,079.40	$291,991.36	$367,369.76
DOC	$23,131.20	$29,102.59	$36,615.50
DOR	$20,695.20	$26,037.73	$32,759.44
EOEA	$1,069.20	$1,345.22	$1,692.49
OMIS/BCS	$148,714.92	$187,106.10	$235,408.08
RCN	$42,031.20	$52,881.67	$66,533.23
RMV	$25,027.20	$31,488.04	$39,616.77
TREASURY	$1,056.00	$1,328.61	$1,671.59
TRIAL COURT	$58,926.12	$74,138.07	$93,277.02
TOTAL	$1,366,890.44	$1,719,757.11	$2,163,717.33

This table assumes NO network growth and a relatively stable rate increase.

ABSTRACT
TABLE 2
3/85

PROJECTED DATA CENTER CAPACITY
17.4% COMPOUND GROWTH
TEN YEAR FORECAST

DATA CENTER	CURR # OF CIRCUITS	1990	1995
CHSB	368	821	1830
OMIS/BCS	237	529	1179
DES	156	348	776
TRIAL COURT	93	207	463
RMV	53	118	264
DOR	31	69	154
RCN	29	65	144
DOC	28	62	139
EOEA	3	7	15
TREASURY	3	7	15
TOTAL	1001	2232	4979

In the ten-year forecast period, the surveyed data centers' need for communications support will INCREASE FIVE-FOLD.

TABLE 3
3/85

GROWTH OF INTER-LATA CIRCUITS
TEN YEAR PROJECTIONS

YEAR	VOICE	DATA	TOTAL	RATIO OF DATA/VOICE
1984	315	50	365	16%
1985	340	59	399	17%
1986	367	69	436	19%
1987	397	81	478	20%
1988	429	95	524	22%
1989	463	112	574	24%
1990	500	131	631	26%
1991	540	154	694	28%
1992	583	180	763	31%
1993	630	212	842	34%
1994	680	249	929	37%
1995	734	292	1026	40%

Table assumes a 17.4% annual growth in data, and an 8% annual growth in voice.

ABSTRACT
TABLE 4
3/85

PROJECTED DATA CENTER LINE COSTS
17.4% COMPOUND GROWTH
4.7% TELCO RATE INCREASES
TEN YEAR FORECAST

DATA CENTER	ANNUAL 1985	ANNUAL 1990	ANNUAL 1995
CHSB	$814,160.00	$2,284,460.51	$6,409,992.89
DES	$232,079.40	$651,194.14	$1,827,192.82
DOC	$23,131.20	$64,904.09	$182,115.10
DOR	$20,695.20	$58,068.89	$162,936.14
EOEA	$1,069.20	$3,000.08	$8,417.96
OMIS/BCS	$148,714.92	$417,280.83	$1,170,852.88
RCN	$42,031.20	$117,935.81	$330,917.38
RMV	$25,027.20	$70,224.10	$197,042.56
TREASURY	$1,056.00	$2,963.04	$8,314.03
TRIAL COURT	$58,926.12	$165,341.45	$463,933.39
TOTAL	$1,366,890.44	$3,835,372.93	$10,761,715.14

In the ten-year forecast period, the surveyed data centers' need for communications support will INCREASE FIVE-FOLD, while communications costs will increase EIGHT-FOLD.

ABSTRACT
TABLE 5
5/30/85

PROJECTED DATA CENTER LINE COSTS
COMPUTED ON SAVINGS OUTLINED IN THIS REPORT
TEN YEAR FORECAST PERIOD

DATA CENTER	CURR # OF CIRCUITS	ACTUAL ANNUAL 1985	PROJECTED ANNUAL 1990	PROJECTED ANNUAL 1995
CHSB	368	$814,160.00	$2,038,040.89	$4,196,875.20
DES	156	$232,079.40	$507,185.95	$1,101,182.00
DOC	28	$23,131.20	$52,683.28	$102,839.85
DOR	31	$14,661.60	$21,218.31	$53,816.45
EOEA	3	$1,069.20	$2,413.14	$4,710.54
OMIS/BCS	237	$148,714.92	$331,800.37	$759,113.86
RCN	29	$42,031.20	$72,478.85	$174,640.05
RMV	53	$25,027.20	$33,239.82	$84,306.86
TREASURY	3	$1,056.00	$2,540.44	$5,515.70
TRIAL COURT	93	$58,926.12	$129,368.95	$295,978.47
TOTAL	1001	$1,360,856.84	$3,190,969.99	$6,778,979.05
TOTAL TABLE 4		$1,360,856.84	$3,818,443.19	$10,714,211.78
PROJECTED SAVINGS		$0.00	$627,473.20	$3,935,232.73

This table computes future data center
line costs incorporating the savings garnered through
the cross-state pipeline and other techniques
(e.g. multiplexing, multi-drop lines).
Compare the totals here with the preceeding
Table 4.

III. RECOMMENDATIONS

A. MODEMS

Background

One result of divestiture in the marketplace has been the production of more sophisticated, less costly data communications equipment by a large number of vendors. In response, OMIS, through a competitive procurement, established a contract for data communications devices.[1]

Findings

During this study, 292 rented Bell modems were identified. These were in use in five of the Commonwealth's major data centers, with 78% located in one data center alone. Replacing all 292 of the rented modems with their contract counterparts would yield a savings of $5,548 per month if the new modems were rented month-to-month ($66,576 per year), or $22,484 per month on a five year lease ($269,808 per year).[2]

---

[1] The contract is a Major Account Agreement (called a "blanket" contract) between the Commonwealth of Massachusetts and a prominent modem manufacturer, enabling the Commonwealth to purchase products at discounted prices.

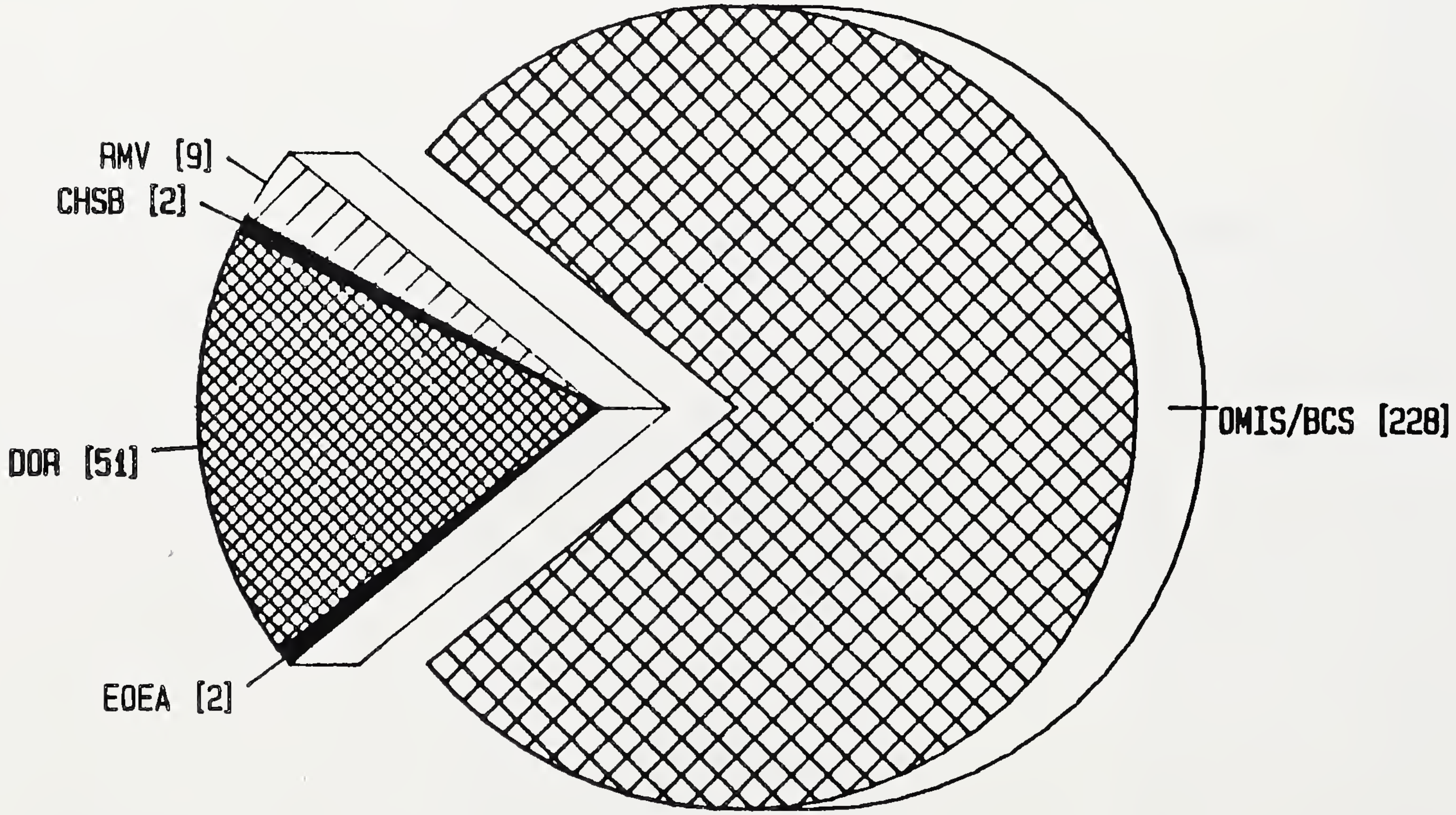
[2] See charts on pages 39 and 40.

Certain features of the contract modems also would permit extensive line diagnostic testing and analysis, contributing to the attainment of higher overall performance in the network.

Recognizing these monetary and technical benefits, OMIS began a program of modem substitution as soon as the blanket contract had been signed.

DISTRIBUTION OF RENTED BELL MODEMS

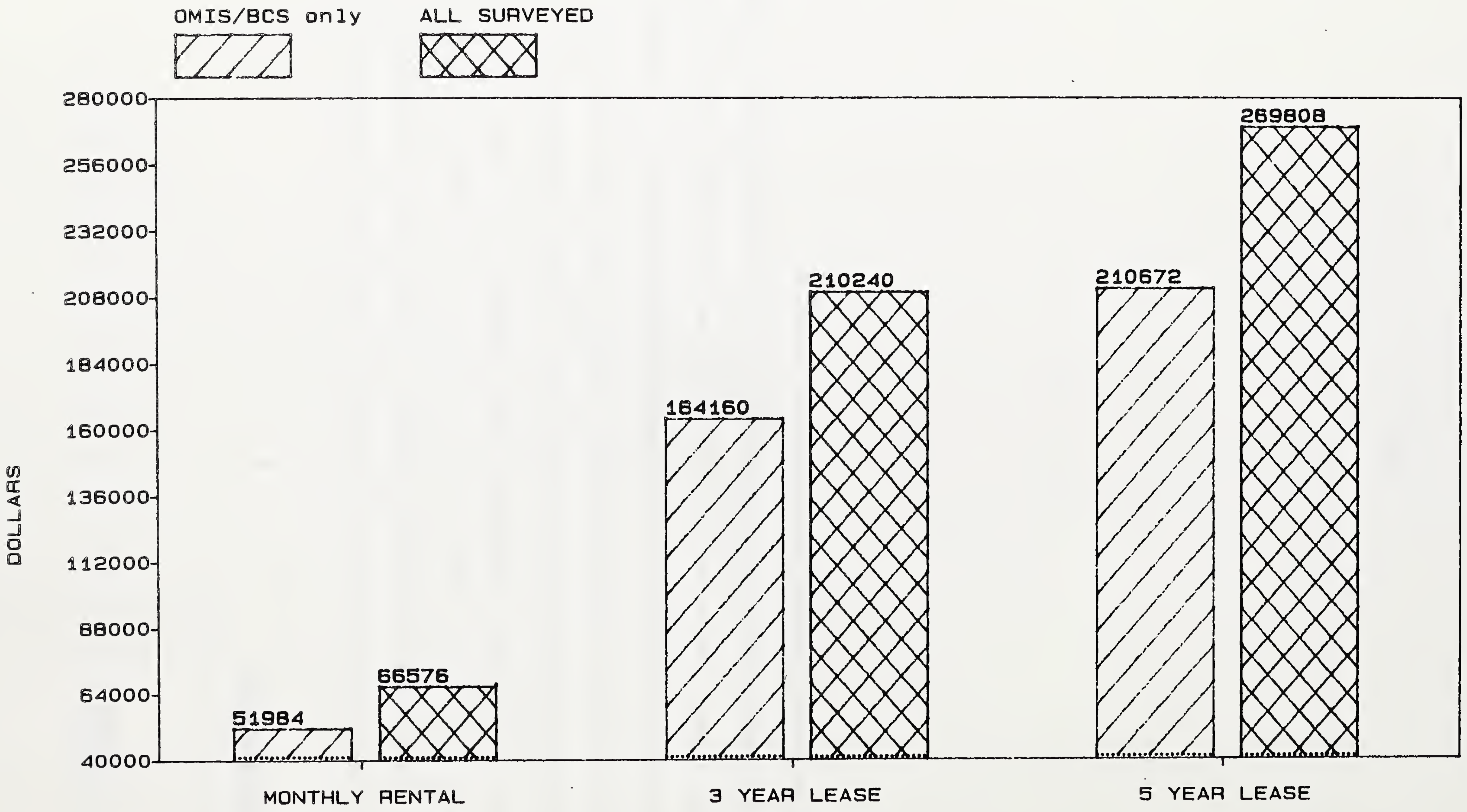
BY DATA CENTER



TOTAL BELL MODEMS - 292

BSPP NETWORK INVENTORY - 2/85

POTENTIAL ANNUAL SAVINGS
MODEM SUBSTITUTIONS
BLANKET FOR BELL MODEMS



BSPP NETWORK SURVEY - 2/85
COMPOSITE - OMIS/BCS AND
SURVEYED DATA CENTERS

B. LINES

Introduction

Particularly in the public sector, where taxpayers' dollars must be used judiciously, the relationship between cost and performance is a crucial factor to be considered in developing any network plan. Cost and growth had to be analyzed for each data center. From the baseline data, a model was created from which predictions on the price and performance of the new network could be made. The model was applied to analyze several different categories: type of line (analog or digital), speed of line, line geometry (point-to-point or multi-point), line equipment and costs of lines and line equipment. In addition, data communications alternatives to the public telephone network, such as packet switching and the use of high capacity (T-1) lines, were considered. Each of these is separately discussed in this section of the report.

TYPE OF LINE: ANALOG VS DIGITAL TRANSMISSION

Definition of Terms

Information can be transmitted over a telecommunications medium in one of two ways, analog or digital. In an analog transmission a continuous range of frequencies is transmitted. The human ear responds to a frequency range of about 30 to 20,000 cycles per second[1], although a much narrower range of 300 to 3400 cycles per second is sufficient to convey both the information content of a message and the identity of a speaker. In a digital transmission a stream of "on" and "off" pulses are sent as discrete entities. Thus, while an analog transmission contains hundreds of different states (frequencies), a digital transmission stream contains only two discrete states.

A circuit can be designed to carry either analog or digital transmissions. This applies to any type of transmission path (wire, coaxial cable, microwave, satellite, and fiber optics). If the path is analog, amplifiers somewhat similar to those used in stereo equipment will be used to increase signal strength. If it is digital, regenerative repeaters will be used to reconstruct and pass on the discrete states ("off" or "on").

---

[1] The technical term Hertz (HZ) is defined as 1 cycle per second.

Trade-Offs

In principal, digital circuits are preferable to analog circuits in that the former can carry higher speed signals over longer distances than can the latter. Furthermore, since computers are digital, to transmit their digital signals on digital circuits theoretically would be the more logical and efficient solution. However, at present most of the communications lines over which the Commonwealth sends data are designed for analog, not digital transmission. In particular, the telephone network has been designed and optimized for voice, which is analog.

As a result, conversion from the current system would be required by the Commonwealth to support digital transmission. In planning such a conversion, a number of factors that affect cost must be taken into account. Several of the most significant are reviewed below.

Telpak Discount. The Commonwealth's current Telpak agreements with New England Telephone cover voice grade lines only, i.e., analog transmissions. To retain use of the Telpak discount requires continued use of analog transmissions. (For additional information on Telpak see the Appendix on page 87.)

Upgrade to Accomodate Speed Demands. Digital telephone circuits must be engineered for a specific speed. To change the line speed of a digital circuit entails its complete restructuring. Analog circuits, on the other hand, can accomodate virtually any line speed from 110 to 14,400 bits per second, depending only on the equipment placed at the ends of the telephone line. To change the line speed of an analog circuit merely entails changing the two modems on the circuit. Therefore, analog lines can be "upgraded" with minimal time and expense to accomodate heavier loads.

Availability. Digital service currently is available in some parts of Massachusetts, but not in others. Many central offices of the telephone company do not have the capacity to handle digital transmissions. Bowdoin Toll, which services the State House area, is one central office that lacks this capability.

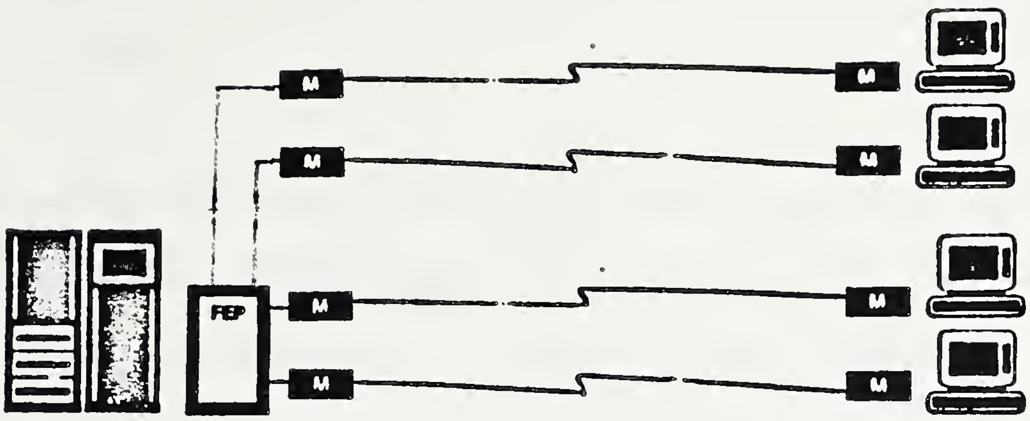
Conclusion

The Regional Operating Companies currently are spending millions of dollars to digitize their local loops. There is no question that the telephone system will become fully digital in the future. Therefore, the pipe-lines proposed in this plan are all digital (see page 57). To be viable, the Commonwealth's Data Communications Plan must both address current demands of an analog telephone system and include a strategy for adjusting to meet the requirements of a fully digital telephone system in the future.

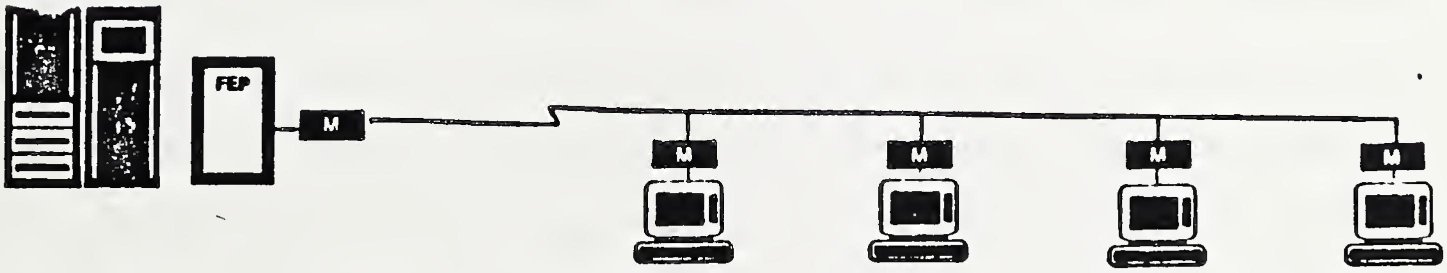
LINE GEOMETRY:
POINT-TO-POINT AND MULTI-POINT CIRCUITS

Definition of Terms

A point-to-point circuit, as its name implies, consists of a modem installed at the host computer site and extended by a leased telephone line to a modem installed at the remote terminal site. Thus, to support one user in the field, two modems and a leased line are required. Although multi-point (multi-drop) circuits also require one modem per user terminal (or terminal cluster controller) and one at the host computer, by means of bridges provided by the telephone company (or other communications carrier) many terminals can be supported on a single line. This simulates a type of time-division multiplexing such that each user perceives himself to be the only one on the line. Exhibits 1 and 2 on the following page provide a pictorial comparison between an actual point-to-point circuit and an actual multi-drop circuit, both currently in use within the Commonwealth.



Point-to-point circuits from DOR to support four users in Westboro. The circuits involved are 70FDDT52532, 70FDDT52533, 70FDDT52534, and 70FDDT52535, which together cost $1376.16 per month, or approximately $344 per supported user. Note that since four terminals are required at the remote site, eight modems and four leased lines are required.



A multi-point circuit runs from OMIS/BCS to support four users, one in Westboro, one in Lowell, one in Quincy, and one in Boston. The circuit, Number 62FDDT3514, costs a total of $924, or approximately $231 per user. Compare with the Exhibit above. In both instances, four terminals are being serviced, but here five (not eight) modems are required, and only one (not four) leased line is used.

In the previous comparison, the cost of the point-to-point circuit is 149% the cost of the multi-point circuit.

Most communications requirements within the Commonwealth are those of terminal to host computer; it is these that will benefit most from multi-point circuitry. Not all point-to-point circuits currently used by the Commonwealth can be eliminated; most computer-to-computer links require point-to-point circuits. Furthermore, several asynchronous computers currently in use cannot handle the complex techniques required to support multi-drop lines. In the latter case, however, the number of point-to-point circuits can be reduced through use of multiplexing, another method that allows a line to be shared among many users.

There are significant economies attached to the use of multi-point circuits. Some data centers currently realize savings through extensive use of multi-point and multiplexed circuits. However, other data centers have not taken advantage of these technological options. As the chart on the following page illustrates, of the 388 circuits surveyed, only 104 (27%) are multi-point configurations; the vast majority (73%) are not.[1] The graph on page 50 displays the ratio of point-to-point circuits to multi-drop circuits by data center.

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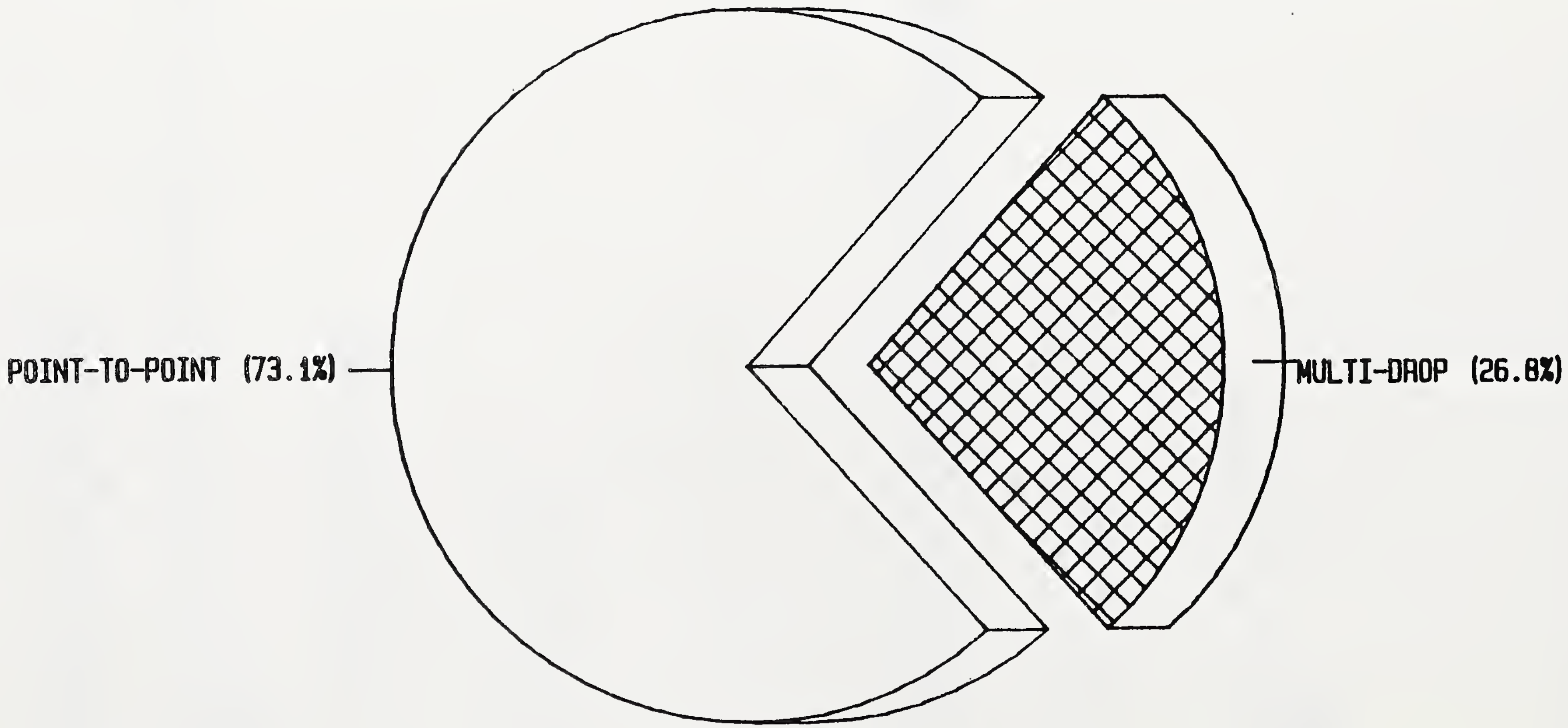
[1] The Lottery, not included in this table, has 2900 terminations, and employs only multi-point circuits.

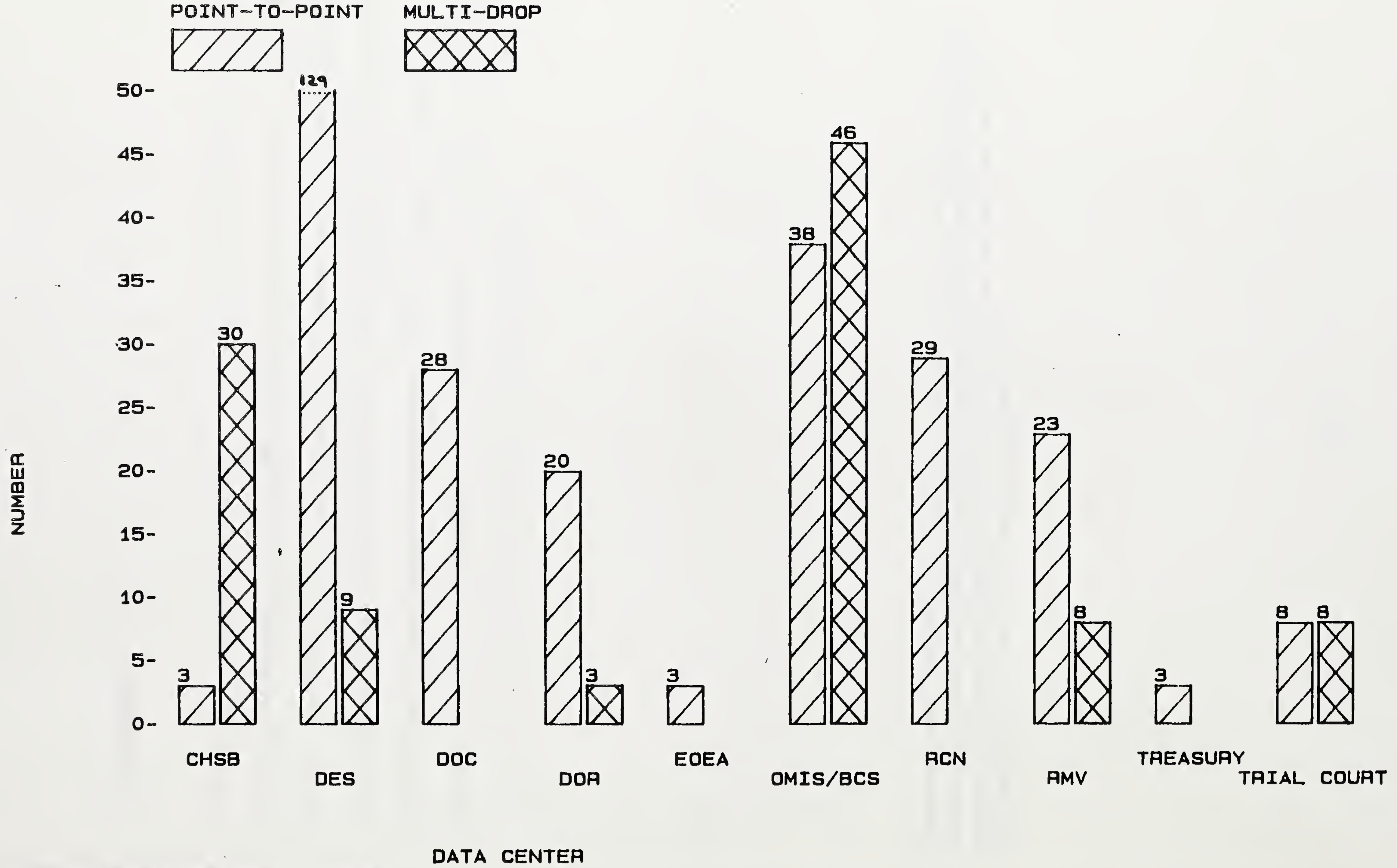
DISTRIBUTION OF MULTI-DROP CIRCUITS



TOTAL CIRCUITS - 388

BSPP NETWORK INVENTORY - 3/85

RATIO OF POINT-TO-POINT VERSUS MULTI-DROP
BY DATA CENTER



BSPP NETWORK SURVEY - 3/85

Conclusion

Often, data communications needs arise serially, and individual point-to-point circuits provide an appropriate initial solution. However, while it is very easy to order and install point-to-point circuits, use of multi-point circuits requires planning and some engineering. Significant savings would accrue were multi-point circuits and multiplexed point-to-point circuits used more extensively. Savings through subsitution of multi-point circuits and multiplexed point-to-point circuits for point-to-point circuits now in use are estimated to be in excess of $3000 per month.[1]

---

[1] This estimate is conservative, taking into account the discount still provided by Telpak pricing in the 617 Area; as suggested by the recent loss of Telpak in the 413 Area, it should not be assumed that this price benefit in the eastern part of the state will last indefinitely. Without Telpak, the savings accrued through the reduction of point to point lines would exceed $12,000 monthly, or $144,000 annually.

PACKET SWITCHING

Definition of Terms

Packet switching is a technique that permits the transfer of data among communicating devices through use of a shared data network rather than a single physical telephone line connection. It allows devices of dissimilar manufacture to communicate among themselves as they rely on the standards imposed on the Packet Assembler Disassembler (PAD) to provide the commonality required for communications. The Regent's Computer Network already employs packet switched links.

Typically, a packet switching network is implemented over leased lines or over other conventional facilities. Several companies currently provide a public packet switching network environment, Tymenet and Telenet being among the largest.

Cost And Service

Public packet networks charge on the basis of use, not distance.[1] There are at present four leased AT&T Long Lines facilities that connect Commonwealth data centers to distant cities. Two point-to-point lines extend from OMIS/BCS to Kansas City, and two multi-drop lines extend from DOR to New York City, Pittsburgh, Chicago, Atlanta, Houston, and Los Angeles. Together, the cost of these four lines exceeds $7000 per month. Also, infrequent users do not require the 24 hour per day availability of leased lines and could benefit from using public packet networks.

Conclusion

The current commercial packet switched network offers a solution for data communication as transparent as, and analogous to, the public switched telephone network for voice. Both Tymenet and Telenet boast very high ratios of service and uptime at competitive prices. Not only can packet switching service long distance users; it may be cost effective for infrequent across-state users, as well.

---

[1] Thus, sending information to Los Angeles is no more expensive than sending the same sized message to Springfield.

TELEPHONE COMPANY HIGH CAPACITY CIRCUITS

Definition of Terms

T-1 is a digital circuit, engineered by the telephone company on two "twisted pairs", that provides large volume transmission between two points at a speed of 1.544 Mbps[1], the equivalent of 24 voice-grade circuits (24 approximately 64 Kbps[2] each). T-1 is not specific to any form of transmission; it can be engineered within any medium (copper pairs, coaxial cable, fiber optic cables, or microwave). It is used for full duplex transmission of serial, bipolar, return to zero, isochronous digital signals, and is at least 95% error free.

T-1 is the North American standard for digital communications and has been in use since 1962 to provide trunk facilities for the old Bell System. There are currently over 120 million miles of T-1 line in place and in daily use. Most toll calls are carried over T-1 circuits.

---

[1] Mbps = megabits (million) per second.

[2] Kbps = kilobits (thousand) per second.

T-1 trunks offer significant economies of scale in the integration of voice and data transmission between major hubs of a network. Voice compression and multiplexing offer significant increases in the cost-effectiveness of a T-1 trunk, increasing its capability. A 2:1 compression of voice allows a single T-1 to carry 44 high quality voice circuits and 60 full duplex 9600 bps data circuits.

For the last two years, T-1 has been available for purchase or lease from Western Union, GTE, ATT-COM, and others. The availability of interface equipment from other vendors (particularly from the Blanket Contract) extends the economic advantage of T-1. T-1 circuits are available as total-service circuits (where a complete turn-key system is provided) or as transport circuits (where the user assembles his own interface equipment).

The T-1 is capable of supporting one hundred and fifty 9600 bps data communication users, and its cost is commensurate with that of about five rented 9600 bps circuits.[1] Therefore, whenever there are more than five data circuits terminating in a building or area, T-1 is likely to be cost-effective. Given that in the Commonwealth's current network 88 data circuits were found to cross the LATA boundary, use of T-1 circuits certainly would be appropriate from a cost effectiveness perspective.

---

[1] See the article contained in the Appendix on page 92.

T-1, however, is a point-to-point transport mechanism; by tariff, it must begin and end on the customer's premises. This means that the T-1 circuit cannot, by itself, be a pipe-line with a drop off in Framingham, Worcester, Springfield, and Westfield; it is an end-to-end, all or nothing facility. T-1 circuits must be viewed and used within a broader network perspective. Although they may not have the capacity to be used for the pipe-line, they can function adequately as feeders from the pipe-line to areas that have a concentration of data communication needs. Other options for use in implementing a pipe-line are considered in the section that follows.

Conclusion

The telephone company has high capacity circuits available as tariffed items. These circuits, designated T-1 circuits, are available with a relatively short lead-time. T-1 circuits could be used effectively as feeders from the pipe-line that serves as the backbone of an East-West network.

C. INTER-LATA

Definition of Terms:

A pipe-line is a generic concept fundamental to any new network design. Any high capacity transmission medium could be used (telephone trunk lines, T-1 circuits, microwave, coaxial cables, or fiber optic cables). As its name implies, a pipe-line is a high capacity pipe, or channel, used to connect two areas. Smaller feeders emerge from the pipe and run to the end-user site. A data communications pipe-line would service the Commonwealth in the same way that a large water pipe serves a residential home, joined at the residence with smaller feeders to the sinks, dishwasher, shower, toilet, etc. As in the water analogy, data communications junctions or gateways would be required that allow feeders in and out. Instead of attaching smaller diameter water pipes, telephone company local loops or T-1 circuits would be attached at these gateways. Thus, a signal starting at a user terminal would be carried by the local loop to a point of connection to the pipe-line (the gateway), would pass through the pipe, and would exit via another gateway to a local loop connected to a data center.

High transmission media options are considered, below.

Findings

T-1 Circuits. T-1 circuits present a very attractive interim solution because they can be obtained in a short period of time. However, their utility over the long term is circumscribed for two reasons. First, because they must be leased from the telephone company, their costs cannot be stabilized or controlled. Second, to expand capacity would require additional circuits.

Microwave Circuits. Microwave has been the major transmission medium for long distance telephone transmission. Even though the future for data communications on microwave is circumscribed by the availability of frequency resources and other less expensive transmission options, microwave remains the standard by which all other transmission media are judged. However, microwave suffers from several disadvantages, enumerated below.

Microwave systems require extensive towers as well as expensive and scarce real estate. Tower costs vary with locale due to the variation in required distance between hops. Environments with high winds and extreme temperatures require tower designs which resist twist, sway, expansion, contraction, and icing. Installations in salt air environments require extensive corrosion protection.

Atmospheric conditions such as fog, snow, and rain may limit the practical distance between towers or dictate the frequency, power, and antennas that must be used. Towers are not practical where large bodies of water are involved; transition to another modality becomes necessary. Even after microwave installations are successfully completed, later changes in the environment can cause problems. Buildings may be erected that effect transmission path.[1] Ecological changes, such as the draining of swamps or changes in the intervening vegetation, including seasonal changes, also can cause transmission problems.

The security of microwave systems is another major concern. With the correct equipment it is relatively easy to intercept a microwave signal. Federal authorities have advised agencies that are seriously concerned about the privacy of their microwave communications to employ data encryption schemes for their transmissions; however, this further increases the cost of microwave delivery systems.

Another limitation of microwave is that at each antenna hop the microwave signal is amplified, thus allowing for the ingress of noise and the subsequent reduction in the signal-to-noise ratio.

---

[1] This is not an academic problem. Currently, the DPW microwave system that terminates at 100 Nashua Street cannot be expanded due to the construction of the Middlesex Court House. As a result, the DPW is actively seeking an alternative antenna location to replace Nashua Street.

Cost is another major issue. The State of Florida, in an extensive study, compared the installation of a microwave transmission system for data communications to that of a fiber-optic circuit. Their study included an insightful examination of cost per delivered capacity. In almost all cases, the fiber-optic system was less costly to build and maintain than the microwave system, and delivered much more capacity. As a result of these findings, except for one link where installation of fiber was impractical, the entire new plan for the Florida data communication system SUNCOM will be fiber-based.

Fiber Optics. Modern fiber optics began in the early 1970's as the merging of two unrelated disciplines: semiconductor technology, which provided the necessary materials for the light sources and detectors, and optical waveguide technology, which provided the medium, the optical fiber cable itself.

Fiber optics is one of the most promising of all of the new technologies for data communications. Although further laboratory tests will continue to improve fiber optics as a technology, commercial usage has been immediate and extensive. Fiber optics' escalating use is predicted not just to influence, but to revolutionize the data communications industry. This is because fiber optics overcomes many of the limitations imposed by other technologies; the weight, strength, and electrical resistance of copper wires, and their susceptibility to Radio Frequency Interference, Electromagnetic Interference, and sabotage; the similar problems of coaxial cable; and the transponder, weather-related, and bandwidth limitations of microwave. A recent ADL study predicts

that fiber optics will replace copper (in all forms) as the single most common communications medium.[1]

> Fiber Optic systems compete economically with microwave and have so underpriced coaxial cable in the United States that AT&T Technologies, the manufacturing arm of AT&T, has stopped making coaxial systems.

Frost and Sullivan estimated that the fiber optics industry will exceed $285 million in 1985, and grow to over $1 billion by 1990. AT&T reported in the May 1984 issue of Business Week that its optical fiber installation jumped from 3740 miles in 1980 to over 200,000 miles in 1983. Other communications companies including GTE and MCI added an additional 50,000 miles of fiber optic cable that year.

---

[1] "Future Telecommunications Technology", Arthur D Little, Reference Number 52552.

Conclusion

It is not serendipitous that fiber optics is beginning to take over the realm once held by copper and microwave. Fiber optics is highly touted because it has numerous technical advantages over both traditional (copper), and non-traditional (microwave) transmission media alternatives. These advantages include capacity, immunity from electromagnetic interference and radio frequency interference, resource availability, ballistics, security, non-flammability, and reliability of data transfer. These are discussed in the Appendix on page 89.

Fiber optics compares favorably with both conventional 12 GHz[1] and state-of-the-art 18 GHz microwave technology. Using a conservative rating of 140 MHz capacity, fiber optics will deliver over three times the capacity of the 18 GHz microwave system operating at a DS-3 rate (44.7 Mbps). Furthermore, unlike microwave systems, fiber optics transmissions are not adversely effected by poor weather.

---

[1] GHz = giga (billion) Hertz.

GATEWAYS

In order to increase the efficiency of data processing statewide, the Office of Management Information Systems is establishing a policy that entails interconnection of all Commonwealth data centers. This will enable a user with a single terminal connected to a data center, to pass through, with proper security, to another data center.

As the number of statewide systems (Payroll/Personnel, Inventory, Comptroller's) increases the demand for access to other data centers also will grow. Gateways must be employed to maximize cost-effectiveness of the Commonwealth's data communications.

Procedures for passage from one data center to another must take into account security and statutory requirements, technology, and associated cost options.

Implementation of this new gateway policy will entail building bridges between the largest of the state's data centers during Phase II of the network plan.

As technology improves, any of the state's data centers will be able to function as gateways to any other data center.

The benefits of this policy will be reflected in the reduced cost of system operation, reduced number of terminals required to access a system and associated reduction in physical plant requirements, fewer data links across the state, and in general more cost-effective implementation of mandated statewide systems.

PROPOSED NETWORK

The findings of this study were used to develop a proposed network structure, designed to satisfy the Commonwealth's current data communications needs, with capacity to meet predicted future demand. Technologically, this network would be required to handle the diverse computer protocols and speeds required by the Commonwealth's several data centers, and to be unobtrusive (transparent) to these data centers and their users. Implementation would occur in three phases, as described below.

Phase I

The proposed network calls for a fiber optic pipe-line connecting Boston, Worcester, and Springfield, consisting of three fiber-optic pairs, with one fiber-optic pair continuing from Springfield to Amherst.[1] This pipe-line which constitutes the backbone of the proposed network, would be implemented by April 1986. (See the map of the proposed network on page 67.)

---

[1] Negotiations are now underway between several state agencies and communications companies in an effort to barter rights-of-way for capacity to meet the needs of the Commonwealth. Because of divestiture, new communications companies are competing to obtain capacity with which to compete with the telephone companies. This should be considered an opportunity for the Commonwealth.

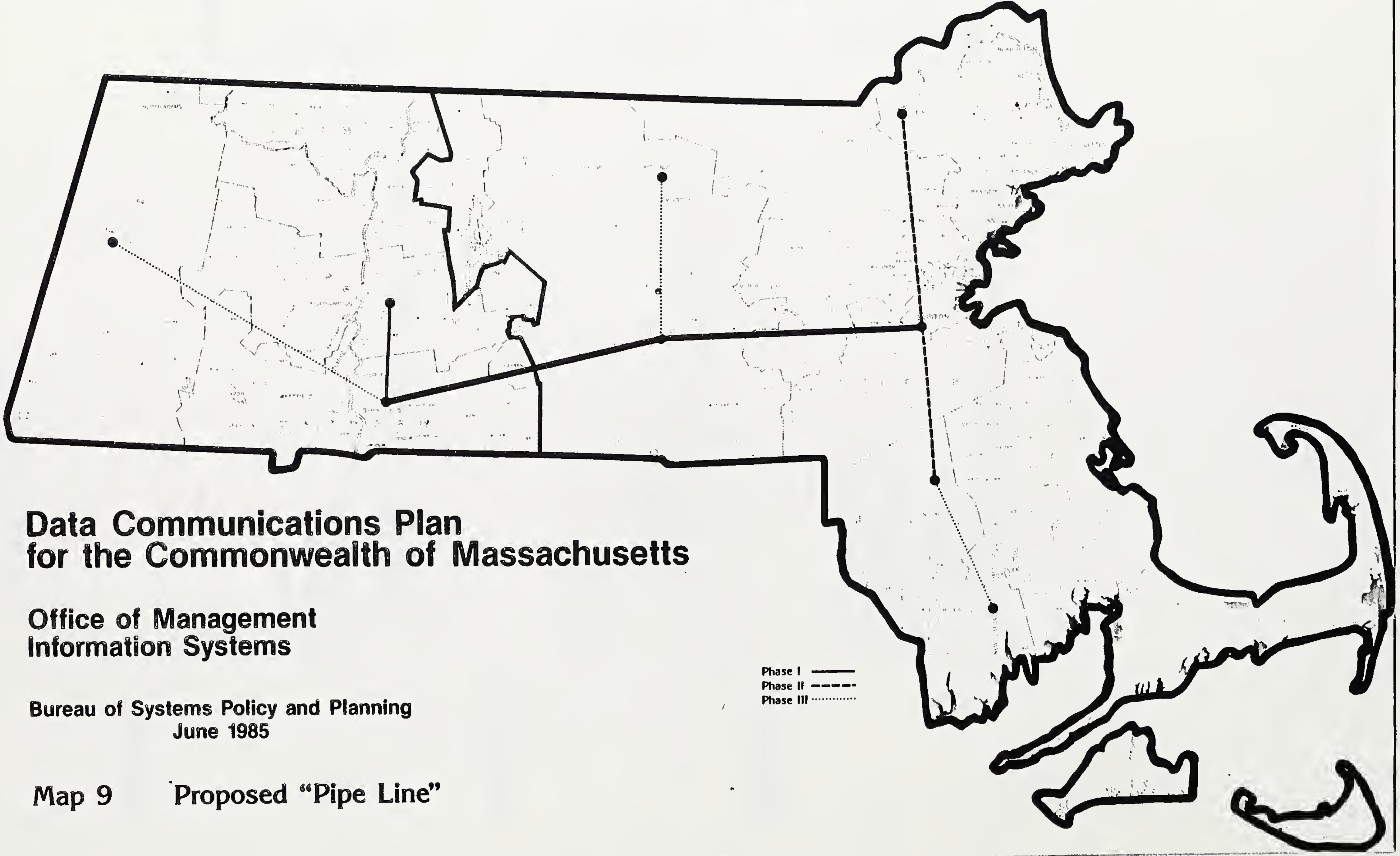
Phase II

During this phase of implementation (April, 1987), the backbone would be extended to include the Lawrence area and the Taunton area, thereby complementing the connection of the eastern portion of the state.

Phase III

During this phase of implementation (December, 1987), the backbone would be further extended to include the Pittsfield, Fitchburg, and New Bedford areas.

The map on the following page details the proposed network and its phased implementation plan. Phase I is represented by solid lines, Phase II by dashed lines, and Phase III by dotted lines. The table and chart that follow outline the breadth of service provided at each phase. Note that overall demand increases over time; thus at Phase III, 70% of the expanded base is covered.



Data Communications Plan for the Commonwealth of Massachusetts

Office of Management
Information Systems

Bureau of Systems Policy and Planning
June 1985

Map 9 Proposed "Pipe Line"

Proposed Pipe Line
Areas of Service

PHASE I

Area	# of terminations
Boston	312
Worcester	89
Springfield	86
SUBTOTAL	487

(49% of the current network load)

PHASE II

Lawrence	66
Taunton	53
SUBTOTAL	119
TOTAL	606

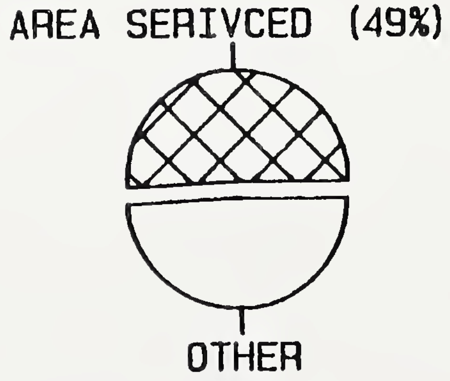
(61% of the current network load)

PHASE III

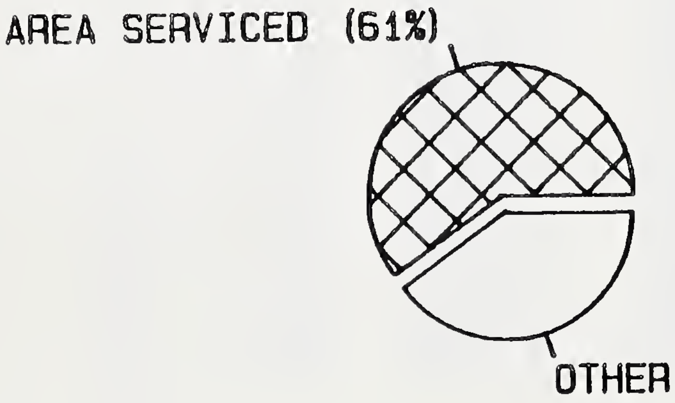
Pittsfield	26
Fitchburg	29
New Bedford	35
SUBTOTAL	90
TOTAL	696

(70% of the current network load)

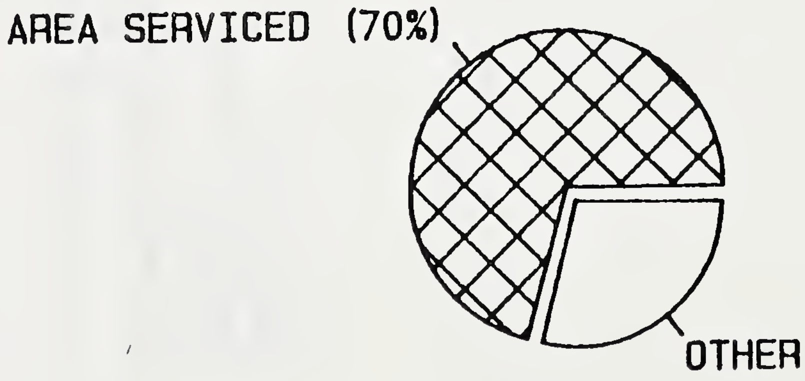
OMIS PROPOSED NETWORK SPINE
LEVEL OF SATURATION



PHASE I



PHASE II



PHASE III

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Credit is herein given to the following information sources:

Chorafas, Mimitris. Designing and implementing local area networks. N.Y. :McGraw Hill, c1984.

Future Information Technology - 1984: Telecommunications. Kay, Peg and Powell, Patricia, ed. Gaithersburg, MD: National Bureau of Standards, c1984. NBS Special Publication 500-119.

Future Telecommunication Technology, -1984. Cambridge MA: Arthur D Little. Reference # 52552

The State Data Communications Plans from:
Florida, Kansas, California, and Maine

and to the following publications and periodicals:

Information Systems News
Datamation
Mini-Micro Systems
Computerworld
Datapro

DATA CENTER CONTACTS

Dept. of Corrections:

Peter Macchi
Dan Buslovitch

Dept. of Employment Security:

Victor Valaitis
Joe Garbino
Chuck Rizzoto

Dept. of Public Works:

Lou Demas
Fred Iarrobino
John Cataldo

Dept. of Revenue:

Steve Winer
Larry Campbell

Exec. Office of Environmental Affairs:

John Shontell
Joe Santos

Exec. Office of Public Safety:
(including the Criminal History
Systems Board)

Louis Sakin
Ron Daneault

Lottery Commission:

Tom O'Heir
Jerry Coffey

Office of Management
Information Systems/
Bureau of Computer Servies:

Bob Ouellette
Cindy Muir

Office of the Treasurer:

Ed Kilgore
Dave Charbonnier
Richard Kelley

Regent's Computer Network:

Jim Corifio
Tony Darrigo
Mark Atkinson

Registry of Motor Vehicles:

David Lewis

Trial Courts:

Richard Wall

University of Massachusetts:

Marty Smith
Ann von der Lippe

DEPARTMENT AND AGENCY KEY

ABBREVIATION	FULL NAME
CHSB	Criminal History Systems Board (now part of the EOPSdata center)
CJIS	Criminal Justice Information System
DES	Division of Employment Security
DEQE	Department of Environmental Quality Engineering
DOC	Department of Corrections
DOE	Department of Education
DOR	Department of Revenue
DMH	Department of Mental Health
DPH	Department of Public Health
DYS	Division of Youth Services
EOEA	Executive Office of Environmental Affairs
EOPS	Executive Offfice of Public Safety
OMIS	Office of Management Infromation Systems
OMIS/BCS	OMIS/Bureau of Computer Services
RCN	Regents' Computer Network
RMV	Registry of Motor Vehicles

THE DATA BASE FORMAT

The next sheet contains the skeleton of the current data file. The field descriptions are as follows:

Screen Name: Telco Circuit ID Field Names : CIRCUIT
Description:
this field contains the actual circuit ID number, e.g., 69FDDT102135

Screen Name: Circuit # Field Name: #
Description:
this field contains a sequential reference number assigned by the telephone company

Screen Name: Lata Field Name: LATA
Description:
this field identifies lines that cross the LATA boundary, 0 = NO, 1 = YES

Screen Name: Source Field Name: SOURCE
Description:
this field identifies the data center which is the source of the data circuit, the default is OMIS/BSO

Screen Name: Dept Field Name: DEPT
Description:
this field identifies the department for whom the circuit is, e.g., Welfare, DSS.

Screen Name: Street Field Name: STREET
Description:
this field contains the street address of the circuit destination.

Screen Name: Town Field Name: TOWN
Description:
this field contains the name of the town of the circuit destination.

Screen Name: MCODE Field Name: MCODE
Description:

this field identifies a multi-drop circuit using the following convention:

MO is the tail circuit (computer to telco)
M5/1 is the first of five lines on the drop
M5/2 is the second, etc.
a blank here indicates a point to pooint circuits

Screen Name: MODEM Field Name: MODEM
Description:

this field identifies the type of modem is use, e.g., BELL 2048A.

Screen Name: Line # Field Name: LINE
Description:

this field contains the address of the circuit source on a computer front end processor, e.g., on the DCP-40 or 3705.

Screen Name: MODEMST Field Name: MODEMST
Description:

this field contains the status of the modem; L = Leased, R = rented, P = purchased

Screen Name: MODEM# Field Name: MODEM#
Description:

this field contains the number of modems in the circuit. Default value = 2.

Screen Name: LINE$ Field Name: LINE$
Description:

this field contains the cost of the circuit that this screen describes.

Screen Name: MODEM$ Field Name: MODEM$
Description:

this field contains the cost of the modem that is described on this screen.

Screen Name: Department Paying Bill: Field Name: BILL
Description:

this field identifies the department that is being charged for the circuit and equipment described on this screen. The default is 'same as Dept'.

Screen Name: NOTES Field Names: NOTES
Description:

this field contains any free text notes to further identify or describe this circuit, e.g., 'computer link to AVCO'. The default is blanks.

THE DATABASE SCREEN FORMAT

```
                              ***********************************
                              *    BSPP  NETWORK  INVENTORY     *
                              ***********************************

       TELCO [CIRCUIT] ID:_____________     CIRCUIT [#]:____    [LATA]: _

       [SOURCE]:_________________________                [DEPT]:__________

  DESTINATION:
     [STREET]:________________________________ [TOWN]:__________________

     [MCODE]:______   [MODEM]:____________    [LINE]# ______ ON HOST SYSTEM

                 [MODEMST] L/R/P _            [MODEM#] _

  COSTS:
                 [LINE$] _______            [MODEM$] _______

                  DEPARTMENT PAYING [BILL]:_________________

        [NOTES]:_________________________________________________
```

MODEM COUNT BY MODEM

MODEM TYPE	SPEED (BPS)	# OF UNITS
ASTROCOM SC200	9600	4
ASTROSET (SHORT HAUL)	9600	4
BELL 108A	150	162
BELL 2048	4800	21
BELL 2048A	4800	237
BELL 2048C	4800	6
BELL 208A	4800	22
BELL 208LA1	4800	2
BELL DATAPHONE	2400	2
BELL DATAPHONE	4800	4
BURROUGHS	1200	38
BURROUGHS	4800	13
CODEX	4800	11
CODEX	2400	8
CODEX LSI48	4800	2
CODEX LSI96	9600	32
CODEX MPS48	4800	13
CODEX SP144	14,400	16
DDS-DSU/CSU	4800	374
IBM 3864	4800	4
INFINET	4800	35
INFINET 96	9600	50
INTERNAL TTY	150	59
LADS (SHORT HAUL)	9600	8
PARADYNE MPX48	4800	78
PARADYNE MPX96	9600	10
PARADYNE T-96	9600	2
RACAL-MILGO MPS9601	9600	4
RACAL-MILGO OMNIMOD	4800	2
RACAL-VADIC 1251	4800	24
RACAL-VADIC SCOTSM	4800	32
SHORT HAUL	9600	4
TIMPLEX 192	19,200	4
	TOTAL:	1287

TABLE 1
3/85

PROJECTED DATA CENTER LINE COSTS
NO COMPOUND GROWTH
4.7% RATE INCREASES
TEN YEAR FORECAST

DATA CENTER	CURR # OF DROPS	CURRENT MONTHLY CHARGES	ANNUAL 1985	1986	1987	1988	1989
CHSB	368	$67,846.67	$814,160.00	$852,425.52	$892,489.52	$934,436.53	$978,355.04
DES	156	$19,339.95	$232,079.40	$242,987.13	$254,407.53	$266,364.68	$278,883.82
DOC	28	$1,927.60	$23,131.20	$24,218.37	$25,356.63	$26,548.39	$27,796.17
DOR	31	$1,724.60	$20,695.20	$21,667.87	$22,686.26	$23,752.52	$24,868.89
EOEA	3	$89.10	$1,069.20	$1,119.45	$1,172.07	$1,227.15	$1,284.83
OMIS/BCS	237	$12,392.91	$148,714.92	$155,704.52	$163,022.63	$170,684.78	$178,706.88
RCN	29	$3,502.60	$42,031.20	$44,006.67	$46,074.98	$48,240.50	$50,507.81
RMV	53	$2,085.60	$25,027.20	$26,203.48	$27,435.04	$28,724.49	$30,074.54
TREASURY	3	$88.00	$1,056.00	$1,105.63	$1,157.60	$1,212.00	$1,268.97
TRIAL COURT	93	$4,910.51	$58,926.12	$61,695.65	$64,595.34	$67,631.32	$70,810.00
TOTAL	1001	$113,907.54	$1,366,890.44	$1,431,134.29	$1,498,397.60	$1,568,822.29	$1,642,556.94

This table assumes NO network growth and a relatively stable rate increase.

(continued)

TABLE 1
3/85
Page 2

PROJECTED DATA CENTER LINE COSTS
NO COMPOUND GROWTH
4.7% RATE INCREASES
TEN YEAR FORCAST CONTINUED

DATA CENTER	CURR # OF DROPS	1990	1991	1992	1993	1994	1995
CHSB	368	$1,024,337.73	$1,072,401.60	$1,122,888.24	$1,175,663.99	$1,230,920.19	$1,288,773.44
DES	156	$291,991.36	$305,714.95	$320,083.56	$335,127.48	$350,070.40	$367,369.76
DOC	28	$29,102.59	$30,470.41	$31,902.52	$33,401.94	$34,971.03	$36,615.51
DOR	31	$26,037.73	$27,261.50	$28,542.79	$29,884.31	$31,288.87	$32,759.44
EOEA	3	$1,345.22	$1,408.45	$1,474.64	$1,543.95	$1,616.52	$1,692.49
OMIS/BCS	237	$187,106.10	$195,900.09	$205,107.39	$214,747.44	$224,040.57	$235,408.07
RCN	29	$52,881.67	$55,367.11	$57,969.36	$60,693.92	$63,546.54	$66,533.22
RMV	53	$31,488.04	$32,967.90	$34,517.47	$36,139.79	$37,030.36	$39,616.77
TREASURY	3	$1,320.61	$1,391.05	$1,456.43	$1,524.09	$1,596.56	$1,671.59
TRIAL COURT	93	$74,138.07	$77,622.56	$81,270.02	$85,090.55	$89,009.80	$93,277.02
TOTAL	1001	$1,719,757.12	$1,800,505.70	$1,885,213.23	$1,973,818.25	$2,066,507.71	$2,163,717.34

(end)

TABLE 2
3/85

PROJECTED DATA CENTER CAPACITY
17.4% COMPOUND GROWTH
TEN YEAR FORECAST

DATA CENTER		CURR # OF CIRCUITS	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
CHSB		368	432	507	595	699	821	964	1131	1328	1559	1830
OMIS/BCS		237	278	327	383	450	529	621	728	855	1004	1179
DES		156	183	215	252	296	348	408	480	563	661	776
TRIAL COURT		93	109	128	150	177	207	243	286	336	394	463
RMV		53	62	73	86	101	118	139	163	191	225	264
DOR		31	36	43	50	59	69	81	95	112	131	154
RCN		29	34	40	47	55	65	76	89	105	123	144
DOC		28	33	39	45	53	62	73	86	101	119	139
EOEA		3	4	4	5	6	7	8	9	11	13	15
TREASURY		3	4	4	5	6	7	8	9	11	13	15
	TOTAL	1001	1175	1380	1620	1902	2232	2621	3077	3612	4241	4979

In the ten-year forecast period, the surveyed data centers' need for communications support will INCREASE FIVE-FOLD.

TABLE 4
3/85

PROJECTED DATA CENTER LINE COSTS
17.4% COMPOUND GROWTH
4.7% TELCO RATE INCREASES
TEN YEAR FORECAST

DATA CENTER	CURR # OF CIRCUITS	CURRENT MONTHLY CHARGES	ANNUAL 1985	1986	1987	1988	1989
CHSB	368	$67,846.67	$814,160.00	$1,000,747.56	$1,230,096.89	$1,512,008.03	$1,858,527.81
DES	156	$19,339.95	$232,079.40	$285,266.89	$350,643.79	$431,003.63	$529,780.10
DOC	28	$1,927.60	$23,131.20	$28,432.36	$34,948.43	$42,957.85	$52,802.84
DOR	31	$1,724.60	$20,695.20	$25,438.08	$31,267.93	$38,433.86	$47,242.05
EOEA	3	$89.10	$1,069.20	$1,314.24	$1,615.43	$1,985.65	$2,440.72
OHIS/BCS	237	$12,392.91	$148,714.92	$182,797.11	$224,690.18	$276,184.23	$339,479.58
RCN	29	$3,502.60	$42,031.20	$51,663.83	$63,504.04	$78,057.77	$95,946.89
RMV	53	$2,085.60	$25,027.20	$30,762.88	$37,813.06	$46,478.98	$57,130.94
TREASURY	3	$88.00	$1,056.00	$1,298.01	$1,595.49	$1,961.14	$2,410.59
TRIAL COURT	93	$4,910.51	$58,926.12	$72,430.69	$89,030.21	$109,433.98	$134,513.84
TOTAL	1001	$113,907.54	$1,366,890.44	$1,680,151.66	$2,065,205.45	$2,538,505.11	$3,120,274.63

(continued)

TABLE 4
3/85
Page 2

PROJECTED DATA CENTER LINE COSTS
17.4% COMPOUND GROWTH
4.7% TELCO RATE INCREASES
TEN YEAR FORECAST CONTINUED

DATA CENTER	CURR # OF CIRCUITS	1990	1991	1992	1993	1994	1995
CHSB	368	$2,284,460.51	$2,808,088.60	$3,451,542.40	$4,242,559.98	$5,214,861.39	$6,409,992.89
DES	156	$651,194.14	$800,433.51	$983,875.26	$1,209,357.83	$1,486,516.03	$1,827,192.81
DOC	28	$64,984.09	$79,778.68	$98,062.20	$120,535.90	$148,160.07	$182,115.18
DOR	31	$58,068.89	$71,377.00	$87,735.04	$107,841.98	$132,556.99	$162,936.14
EOEA	3	$3,080.08	$3,687.63	$4,532.76	$5,571.56	$6,848.44	$8,417.96
OMIS/BCS	237	$417,288.83	$512,912.42	$630,460.66	$774,940.37	$952,549.49	$1,170,852.87
RCN	29	$117,935.81	$144,964.18	$178,186.69	$219,823.15	$269,218.44	$330,917.39
RMV	53	$70,224.10	$86,317.92	$106,188.09	$138,415.89	$168,304.35	$197,842.58
TREASURY	3	$2,963.04	$3,642.10	$4,476.79	$5,502.78	$6,763.89	$8,314.83
TRIAL COURT	93	$165,341.45	$203,234.07	$249,810.85	$307,062.08	$377,433.86	$463,933.39
TOTAL	1001	$3,835,372.94	$4,714,356.04	$5,794,782.73	$7,122,819.44	$8,755,212.96	$10,761,715.15

(end)

PACKET SWITCHING

The concept of packet switching arose from the need to build a data communications network modeled on the telephone network, that would permit data terminal equipment to communicate with an ease of use comparable to that enjoyed by voice users of the telephone. A packet switching network allows terminal users to communicate through any other equipment connected to the network, simply by presenting their data (along with some control information) in a prescribed manner.

Packet switching was first introduced in the late 1960's. At that time, each Packet Data Network defined its own network access protocol to control how devices accessed the network. Each of these protocols employed a multiplexing technique that allowed a computer to establish and maintain one or more virtual circuits to other users in the network. However, there were no industry standards for packet switching systems, and most manufacturers were reluctant to provide the software necessary to handle the growing variety of network access protocols. As a result, packet data networks were left to the realm of the experimenter and research institutions.

In 1976 the International Consultative Committee for Telegraphy and Telephony (CCITT) adopted Recommendation X.25 as a standard for packet switching systems. Since the adoption of X.25 (the name of the committee that studied the problem), packet switching has become a viable, economical technically alternative to conventional leased telephone lines.

In conventional terminal-to-computer communications, data generally are sent in individual character forms, or in streams of characters, with little on no address or control information. While addressing is unnecessary when there is an unbroken piece of wire connecting the terminal to the host computer, in a universe that consists of "virtual wires" and many users, an addressing technique is mandatory. Since packet networks only handle blocks of data, a mechanism is required to convert character strings into blocks and to provide the required addressing and control information. Such a mechanism is generically called a Packet Assembler Disassembler (PAD). A PAD is a functional device which can be implemented using hardware or software, or a combination of the two. IBM Corporation markets a software PAD package for its mainframes called NPSI (NCP Packet Switching Interface); other manufacturers use external hardware devices as PADs. GTE Telenet has sales, lease, and rental arrangements for its PAD "engines". Packet switching is analogous to the postal service. A typical packet contains a header (the envelope with name and address of the proposed recipient and sender) and user data data (letter inside). Once the envelope is removed by the PAD, the user sees only his own data.

A typical message can consist of one or many packets. Multiple packet messages require sequence numbering so that the packets can be disassembled at their destination in the proper order. To accomplish this, packets are placed in frames (outside envelopes) before they are transmitted.

Data are transferred through virtual circuit connections or through permanent virtual circuit connections. A virtual circuit is one in which no single physical link is established between the sender and the receiver. Rather, a logical route of least delay is established by the network to connect the sender and the receiver. The logical circuit is maintained for the length of the virtual call; as each packet is physically transmitted, a temporary (or virtual) link is established through the network to the receiving station. A dedicated path, or permanent virtual circuit, is used for all packets within a single session. The network is aware of the fixed association between the two stations, and permanent logical channel numbers are assigned exclusively to the permanent circuit.

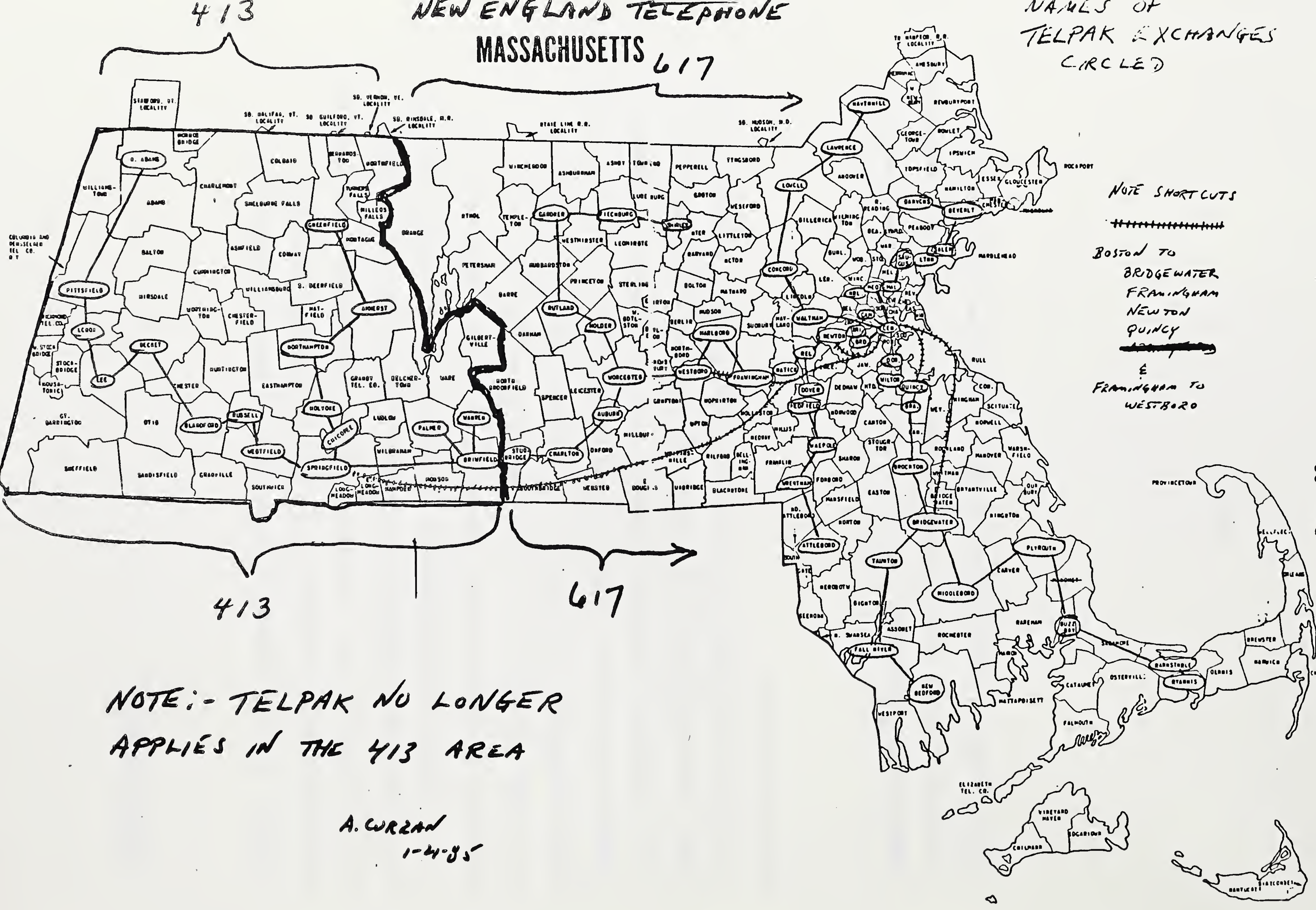
TELPAK

The following illustration is a map of the Telpak facilities in Massachusetts. The dark line is the LATA boundary that separates the 617 area from the 413 area. Circled cities in the western part of the state were formerly serviced by Telpak. Note the very inexpensive "shortcut" that used to exist between Boston and Springfield.

NEW ENGLAND ~~TELEPHONE~~

MASSACHUSETTS

NAMES OF TELPAK EXCHANGES CIRCLED



NOTE SHORTCUTS

++++++++++++ BOSTON TO BRIDGEWATER FRAMINGHAM NEWTON QUINCY

▬▬▬ & FRAMINGHAM TO WESTBORO

NOTE:- TELPAK NO LONGER APPLIES IN THE 413 AREA

A. CURZAN
1-4-85

FIBER OPTICS

Capacity. Fiber optic systems have more capacity, i.e. potential bandwidth, than any other type of system, including coaxial cable. The current bandwidth of a single-mode fiber optic cable is between 400 and 1000 MegaHertz, depending on distance and electronics, and a bandwidth of 50 GigaHertz is expected within the forseeable future. The most recent Bell System long-haul facility is type FT4E, which is the fiber optic version of the DS4E, it uses a single mode fiber and carries 6048 voice circuits over a single fiber optic cable in each direction. Bell reports that these systems compete economically with microwave. In the typical user situation, this enormous bandwidth not only allows a single cable pair to act as the medium for all current voice, data, and video needs, but provides considerable room for expansion to meet emerging needs. To put this into perspective, all of the State's 300 voice and 88 data circuits that cross the LATA boundary can be carried in a small fraction of a single fiber optic pair crossing the State.

Immunity from EMI and RFI. Fiber optic systems are immune from Electromagnetic Interferences and from Radio Frequency Interference. Harsh or noisy environments do not affect the quality of signals on fiber optic cables. Optical cable can be run almost

anywhere; underground, undersea, in elevator shafts, under streets, along tracks, adjacent to flourescent lights, and alongside high voltage wires. Fiber can withstand temperatures in excess of 1000 degrees Celcius and, when aerially installed, is not susceptible to lightning.

Resource Availability. Fiber optic cables are inexpensive. They are made from the most abundant mineral on earth, sand. A single pound of sand will yield over twelve miles of quality fiber optic cable. Copper, on the other hand, is a depleting resource. Microwave systems require extensive tower and antenna arrangements, transponders, and amplifiers.

Ballistics. Fiber optic cable is very light and very thin. A typical strand is 6/1000 of an inch, about the size of a human hair, but possessing the same tensile strength as a steel wire of the same diameter. One kilometer of fiber optic cable weighs about 30 pounds; the same length of copper would weigh over 200 pounds.

Security. Fiber optic cable emits no radiation and is virtually untappable without detection, since signal loss can be detected immediately. Also, breaks in a fiber optic cable can be isolated to within a few inches. This feature alone has led to particular use and development of fiber optics by the military and security conscious government agencies.

Non-flammability. Since fiber optic cables carry no electrical current, fiber may be used without any fear of spark hazard in harsh environments including those with corrosive chemicals, acids, and fuels. Fiber can also be installed in ducts and plenum spaces without the need for additional safeguards.

Reliability of data transfer. As a direct consequence of its immunitive properties, data communication bit error rates are in the order of 10^{-9}, or one error created for every billion bits transmitted. This very low error rate, approximately 1000 times better than current microwave capability, will continue to improve as fiber optic technology continues to be refined. Additionally, since no radiation can leak from a fiber optic cable, it is immune to annoyances commonly experienced with other transmission media, including crosstalk, echoing, and ringing.

T-1's Rise Spurs Supporting Gear, Mux Vendors

By Julia King

As increasing numbers of large corporate users replace leased analog lines with T-1 carriers for use as private data communications system backbones, some industry observers are predicting a new lease on life for time division multiplexers (TDM) and other gear that supports T-1 trunks.

As a result, several hardware suppliers are beefing up their T-1 product lines, offering users an array of T-1 TDMs and network management systems that users said were previously hard to find or altogether unavailable.

"When we installed our first private T-1 system, the only T-1 multiplexer vendor we could find was General DataComm [Industries Inc., Danbury, Conn.]," recalled Robert Gallagher, director of distributed data systems for Westchester County, New York. "Other people were making them, but they were not selling them to end users."

A year later, however, Gallagher said he was able to choose from among more than 10 vendors. Today, he said, "I'd probably be bombarded by more than three dozen manufacturers."

Hardware vendors' new emphasis on T-1 equipment is in part explained by the relatively recent commercial availability of T-1 transmission technology, which digitizes and multiplexes voice communications to allow 24 simultaneous conversations to take place over two twisted-wire pairs. Previously, one wire pair was required for each call.

Developed by Bell Laboratories in 1958, T-1 technology was once used exclusively by AT&T to link central switching offices. In March of 1983, however, T-1 trunks, which allow integrated transmission of voice, data, facsimile and video, were tariffed for commercial use.

This unleashed what one vendor labeled "a large pent-up demand" for the 1.544 Mbit per second transmission capacity of a T-1 line as well as for multiplexing equipment that supports the technology. Thus, vendors' increased emphasis on the gear, noted Bruce Smith, president of Network Equipment Technologies, a Menlo Park, Calif., equipment manufacturer.

"Without the regulation that governed T-1 [prior to March 1983], corporate users would have been migrating to T-1 as early as the 1970s. But because they couldn't, what we have now is really an unnatural situation in terms of demand," Smith said.

A second factor contributing to the popularity of T-1 systems is their cost-effectiveness. (See related story, Page 53.)

As one user pointed out, a T-1 line with a transmission capacity of 1.544 Mbits per second could potentially provide him with as many as 150 9.6K bit per second (bps) channels between an office in White Plains, N.Y., and another in Yonkers, N.Y., at a cost of $1,500 per month. Meanwhile, the alternative to using the T-1's 1.544 Mbits per second capacity would be leasing 150 voice-grade tie lines at an approximate monthly cost of $250 per line.

The user also pointed out that additional savings are realized using a T-1 because the need to install 9,600-baud modems at both ends of each tie line is eliminated. Instead, those modems are replaced with a single T-1 multiplexer at each end of the T-1 line.

Carriers leasing T-1 lines to end users confirm that demand for the technology is definitely on the increase. At Bell Atlantic Corp., Philadelphia, for example, a spokesman said the number of T-1 lines it supplies to end users has more than doubled in the past year.

Similarly, vendors supplying T-1 related equipment said they are selling more and more gear to large corporate customers.

At Timeplex Inc., Woodcliff, N.J., Victoria Brown, vice president of corporate development, said the company's salespeople are now spending about 85 percent of their time talking to customers interested in installing T-1 lines.

By contrast, she said, "If you were to talk about our salesmen's time a year ago, 85 percent of their time would have been spent talking to people interested in statistical multiplexers for 9.6K bps leased lines. Now 85 percent of the customers are talking about T-1—and those sales contacts are driven by customer inquiries."

Brown also noted that the company's customer base is shifting. Traditionally, she said, AT&T, which uses Timeplex products internally and also remarkets them to end users through its Information Systems unit in Morristown, N.J., has been Timeplex's biggest customer.

While AT&T remains the firm's largest client, she pointed out that, "on a percentage basis, AT&T will [this year] comprise a lower percentage of our total revenues than in previous years"—indicating that more end users are buying equipment to support T-1 lines.

Equipment vendors' response to the increased interest in the technology is to direct more money and R&D effort toward the development of more sophisticated T-1 products, she noted. At Timeplex, Brown said, the company will continue to make heavy investments in its Link/1 flagship line of T-1 multiplexers, adding that "certainly a heavy proportion of R&D money is going to Link/1 successor products."

At the same time, other vendors are following suit.

Infotron Systems Corp., Cherry Hill, N.J., said that because of the increased interest, it plans to announce a line of T-1 products by the end of the month. Previously, the company manufactured a TDM under a licensing agreement with Datatel Inc., also of Cherry Hill.

At Codex Corp., Mansfield, Mass., Doug Antaya, product manager for T-1 multiplexers, said he expects to see the T-1 market grow in excess of 25 percent annually over the next five years.

T-1 products that equipment vendors are now offering range from digital transmission multiplexers, such as Insta-trunk 480—a multiplexer from Micom Systems Inc., Chatsworth, Calif., that provides up to 128 9.6K bps channels over a T-1 link—to more sophisticated T-1 network management systems.

Such a network management system is Network Equipment Technologies' integrated digital network exchange (IDNX). Besides multiplexing data, it combines voice compression and management facilities, allowing the dynamic allocation of T-1 bandwidth. Enhanced speech processing also permits up to 4-to-1 voice compression, according to the company.

Observers said customers can expect even a wider range of T-1 equipment in the future, as more and more vendors enter the market.

And, said Codex's Antaya, as "the skyrocketing cost of private lines are bringing more and more customers to look at T-1 carriers," increased usage of the lines will also drive the market toward more sophisticated T-1 related equipment.

"Right now, there are still a lot of products customers need, but they aren't yet on the market," he added, noting that some of those future products would most likely offer enhanced diagnostics capability and the ability to automatically reconfigure a T-1-based network.

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T-1 Can Also Be Cost Effective for Small, Medium-Sized Users

While some industry observers ave questioned the cost-effective-ess of high-capacity T-1 links for ny users other than those with uge volumes of data traffic, the irector of distributed systems for Vestchester County in New York naintains that a customer need ot initially use the entire capaci-y of a T-1 link in order to reap ertain economic benefits.

According to Robert Gallagher, who oversaw the installation of Westchester County's first T-1 system last April, small and medium-sized users can realize cost savings by replacing leased analog lines with T-1 carriers even if they use as little as 5 percent of the T-1 pipe's 1.544 Mbit per second transmission capacity.

"You really don't have to use the whole thing to make it economical," Gallagher said, noting that when one calculates in the cost of equipment associated with the use of leased analog lines, T-1 pricing, albeit higher on a monthly basis, becomes quite cost beneficial in the long run.

By way of example, Gallagher offered the case of a customer leasing five 9.6K bit per second (bps) voice-grade tie lines at an average monthly cost of $250 each or $1,250. For each of those lines, Gallagher also pointed out that a customer would need five pairs of 9,600-baud modems, which he estimated would cost between $20,000 and $25,000.

By contrast, a customer leasing a T-1 line at an average monthly cost of $1,500 could accommodate those same five 9.6K bps lines as well as 145 other identical lines—should he need additional capacity—using the 1.544 Mbits per second capacity of a T-1. Equipment costs associated with the T-1 would average about $30,000 and include a T-1 multiplexer with five channel cards at each end.

At Datatel Inc., a Cherry Hill, N.J., manufacturer of T-1 multiplexers, Tom Hornsby, national sales manager, agreed, saying, "A good rule of thumb is that a T-1 can be cost justified with five 9.6K bps channels." And beyond that, he noted, "Any voice or data you add to the T-1 is dirt cheap."

While cost savings is the number one factor vendors mention when discussing T-1 lines, Hornsby noted other advantages, including the ability to combine voice and data networks, thus permitting both networks to be monitored simultaneously; the capability for video conferencing; and the opportunity to decrease the amount of installed wiring.

And, users will increasingly demand that capability, according to Bob Bauer, vice president of Infotron Systems Corp., Cherry Hill, N.J., who, like Gallagher and Hornsby, said medium-sized users can indeed justify use of a T-1 even if they do not initially require the pipe's full capacity.

As the use of T-1 lines becomes more sophisticated, Bauer also noted that customers are also bound to require more sophisticated T-1 multiplexing equipment.

"Initially, we think customers want relatively simple point-to-point T-1 solutions," he said. But, down the road, when T-1 lines will be supporting faster equipment requiring higher bandwidths, he said he expects that customers will want multinode T-1 networks.

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